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POPULAR ASTRONOMY

PLAINLY WORDED AND LARGELY UNTECHNICAL IN LANGUAGE. AMPLY ILLUSTRATED.

ISSUED MONTHLY EXCEPT JULY AND AUGUST
ANNUAL VOLUME (10 NUMBERS.)

VOL. XIV.

1906.

EDITORS:
WILLIAM W. PAYNE, H. C. WILSON.

OFFICE OF PUBLICATION:
GOODSELL OBSERVATORY OF CARLETON COLLEGE,
NORTHFIELD, MINNESOTA,
U. S. A.

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PLATE I.

RALPH COPELAND.

(1837–1905.)

Popular Astronomy.

Vol. XIV No. 1. JANUARY, 1906. Whole No. 131.

RALPH COPELAND.

HECTOR MACPHERSON, JUNIOR.

FOR POPULAR ASTRONOMY.

Astronomy has sustained a severe loss in the death of Dr. Copeland, Astronomer-Royal of Scotland and Professor of Astronomy in the University of Edinburgh, which took place in Edinburgh on October 27th last. The son of a farmer, Ralph Copeland was born at Moorside, near Woodplumpton, Lancashire, September 3, 1837. He received his education from a handloom weaver, and afterwards in the Grammar School of Kirkham; and while still a lad, was seized with a passion for travel. Accordingly he emigrated to Australia in 1853, and spent several years as a shepherd at the foot of the Australian Alps. In the solitudes of Australian plains his attention was attracted to the wonders of the heavens and he sent home to England for a small telescope, with which he commenced the study of Astronomy. After spending some time at the gold-diggings in the Omeo district, he returned to England and on the voyage home was the first to observe Donati's comet. On his return, he was apprenticed to a firm of locomotive engineers and in conjunction with some of those in the employment, he succeeded in founding a small observatory. In 1864, in consequence of the depression of trade following on the American Civil War, he went to Germany for the systematic study of astronomy. He entered the University of Göttingen where Professor Klinkerfues was among his teachers. In 1867 he became volunteer assistant in the Göttingen Observatory.

Here, in conjunction with Dr. Börgen, now director of the Observatory at Wilhelmshaven, Dr. Copeland did useful work in the observations for the first Göttingen star-catalogue, which was published in 1869. Some time later, Dr. Copeland became a member of the German Arctic expedition which was sent to explore the coast of East Greenland. In Greenland two small observatories were built, and there Dr. Copeland along with the

other members of the scientific staff, took meteorological observations hourly. On his return to Germany he received, with other members of the expedition, the Order of the Red Eagle from the Emperor Wilhelm I.

In 1870 Dr. Copeland left Germany, on becoming astronomical assistant to the younger Earl of Rosse at Birr Castle in Ireland. Here he remained for three years and a half, investigating the heat of the Moon and other important subjects. In 1874 he was appointed assistant to Dr.—now Sir—Robert Ball at the Dunsink Observatory, in Dublin; and in the same year he was commissioned by Lord Lindsay—now Earl of Crawford and Balcarres—as a member of the Scottish expedition sent by him to observe the transit of Venus from the Island of Mauritius in December 1874. In 1876 Dr. Copeland went as astronomer to Lord Lindsay's private observatory at Dunecht, in Aberdeenshire, where he remained for thirteen years, and where his most important work was accomplished. In 1880 he devised—independently of Professor Pickering — the new spectroscopic method of discovering very faint nebulæ. In 1882 he specially studied the "great September comet", identifying six brilliant rays in its spectrum with the prominent lines of iron, and thus confirming Brédikine's theory of the classification of comets. He also measured the radial motions of comets by means of Doppler's principle. In December 1882, he went to Jamaica to observe the second transit of Venus in the nineteenth century, and in the following year he spent six months on the Andes of Peru and Bolivia in order to test the advantages of observations at high altitudes. While on this expedition he discovered five gaseous Wolf-Rayet stars and carefully mapped the spectrum of Gamma Argus.

In 1886 Dr. Copeland made his greatest discovery, that of helium in the great Orion nebula. Helium had been discovered by Sir Norman Lockyer in the Sun in 1868, but Dr. Copeland's discovery was the first hint that it was widely diffused throughout the Universe. In 1887 Dr. Copeland was appointed by Lord Crawford and Balcarres to observe the total eclipse of August 19, 1887, visible in central Russia, but unfavorable weather frustrated the intention of the expedition.

Professor Piazzi-Smyth, Astronomer-Royal of Scotland resigned his post in 1889, and Dr. Copeland was appointed to succeed him, being third Astronomer-Royal and Professor of Astronomy in the University of Edinburgh. The Royal Observatory of Scotland was at that time the famous institution on the Calton Hill,

Edinburgh, but at the time of Dr. Copeland's appointment arrangements were being made for the erection of a new Royal Observatory on the summit of Blackford Hill, and the conversion of that on the Calton Hill into a City Observatory. Lord Crawford, who had now given up the Dunecht Observatory, promised to equip the new Royal Observatory with his magnificent instruments and library. The first years of Dr. Copeland's residence in Edinburgh were occupied in superintending the erection of the new institution, which was opened in 1896. Accordingly Dr. Copeland left the Calton Hill to direct the new observatory, his successor on the Calton Hill being Mr. William Peck, the well-known Scottish astronomer, who received the title of Astronomer to the City of Edinburgh.

Since the new observatory was opened Dr. Copeland directed three eclipse expeditions. The first of these official Scottish expeditions, to observe the eclipse visible in Norway on August 9, 1896, was frustrated by cloud; but Dr. Copeland was more fortunate in India on January 22, 1898 and in Spain on May 28, 1900. Much valuable work has been done at the observatory since its opening, particularly in the spectroscopic department, and in celestial photography. Dr. Copeland was ably assisted by the late Mr. Ramsay, by Mr. Heath and by Dr. Halm, the latter of whom has made important studies of the Sun's rotation and of the cause of new stars. In 1901 Dr. Copeland's health broke down altogether, and he was latterly unable to take an active part in observing. His death was therefore by no means unexpected.

Dr. Copeland's work was not of the kind that attracts popular attention; but he will be remembered as a skillful and laborious investigator, who reached a high position in astronomical science, unaided by opportunity or by technical education. Like most of the astronomers who have labored in Scotland, Ralph Copeland was a self-made man.

THE COMING TOTAL ECLIPSE OF THE MOON.

WILLIAM H. PICKERING.

FOR POPULAR ASTRONOMY.

The object of this paper is to call the attention of astronomers to the desirability of making certain observations upon the little crater Linné which are possible only at the time of a lunar

eclipse. While it is probably true that few professional astronomers feel any interest in the Moon, or would even care particularly if it should disappear altogether, in fact rather the reverse; yet it is nevertheless desirable, since they are in general the only persons who can make the observations, that they should take advantage of this occasion to make some measures such as are suggested below.

While several observers have proved that the size of the white spot surrounding Linné is dependent on the time that the Sun has shone upon it, or more accurately expressed, on the colongitude of the Sun as seen from the Moon, there are only four who have measured Linné at the time of a total eclipse. These four Messrs. Douglass, late of the Lowell Observatory, Saunder of Crowthorne, England, Wirtz, of the Strassburg Observatory, and the writer, all agree that the white spot appears larger after it has emerged from the Earth's shadow then it did before it entered it. It is nevertheless very desirable that the number of these observations should be increased, and the amount of the enlargement measured.

The first described observation, that depending on the age of the Moon, is comparatively easy, indeed a pair of good lunar photographs, one taken soon after the first quarter, the other near full Moon, will generally make the change in size of the spot fairly clear, the law being in general the higher the Sun, the smaller the spot. The range in size amounts to between 2″ and 3″. The other observation, that made at the time of an eclipse, is by no means so simple. The last total lunar eclipse visible in America was in October 1902. At that time I requested the coöperation of other American astronomers in the observations, but although the weather was clear, and the eclipse generally observed, no one else thought the matter of sufficient interest to make any measurements. This was unfortunate since the range in size before and after totality was phenomenally large that year, 2″.8, and therefore readily detected. On the other hand in 1899 the range of size was only 0″.14, the change being comparatively inconspicuous. On the two other occasions when it has been measured it has proved to be rather over half a second.

It is very desirable that some observations should be secured this year, and it is recommended that for an hour or so, both before and after the shadow transits Linné, as many micrometer measures as possible should be taken, all in an approximately north and south direction. Measures in this position angle are more accurate than those in an east and west direction on account

of the motion of the Moon in its orbit. Owing to the haziness of the edge of the white spot surrounding the crater, a few observations should be taken on previous nights, to familiarize the observer with the difficulties of the investigation. A more detailed account of the earlier observations will be found in the Harvard Annals LI, 24. Dr. Wirtz's observations will be found in the Annals of the Strassburg Observatory III, appendix C.

Rather conspicuous changes occur in the white spots near the center of Eratosthenes in the course of a lunation, and it is possible that observers not possessing micrometers might find that these spots exhibited some slight change during the passage of the shadow of the eclipse. This is offered merely as a suggestion, for no one has ever looked for such a change as far as the writer is aware. The identification of Eratosthenes at full Moon is somewhat difficult, and may be most easily assured by means of the photographic atlas published at the end of the Harvard Annals LI, and also in the writer's book on the Moon.

November 20, 1905.

THE COLOR OF THE SKY.

W. W. PAYNE.

For Popular Astronomy.

In a recent book by Thomas Curran Ryan with the title "Finite and Infinite", considerable space is given to the interesting theme, the color of the sky. In the first chapter of the second part of the book, reference is made to an article, on the same subject, which was prepared by this same author and sent to Popular Astronomy in 1894. The article was not published, but a synopsis of it was given, that the author might have the benefit of such a notice, promptly and rightfully to establish his claim to whatever was new or important in it.

The conclusions and the arguments that were then set forth, and which are given in the book referred to, will be found on page 167 and those following. We give below a statement in his own language:—

"1. The sky is beyond the stars.

"2. The sky is matter of some sort.

"3. The sky is probably an infinite depth of gas surrounding the sidereal system, and composed of the same material elements from which stars and planets were evolved.

"The facts which appear to prove the first of these propositions,

viz: that the sky is beyond the stars, are as follows:—

1. The sky has color; 2. The blue of the sky becomes intensified to the eye when observed from the tops of mountains, or in elevated regions, where there is scarcity of vapor and rarity of atmosphere; 3. The blue of the sky does not intercept or impair the light of the stars. The light of the stars is not blue as if it came through a blue medium. Any substance capable of color, and occupying the space between us and the stars in sufficient quantity to look as blue as the sky, must have such density in the line of vision that it would either shut out the light of the stars altogether, as a blue cloud would do, or at least seem to do so, by permitting none but blue rays to come to us. The fact that the spectrum of a star's light discloses all the rays, conclusively proves that this intensely blue thing which we call the sky is not between us and the stars.

"The conclusion that the sky is matter of some sort seems to be a necessary deduction from the fact that it has color. Color is the result of the coming together of matter and light waves. Color has never yet been found separated from matter.

"If the sky is matter of some sort, and is beyond the stars, the inquiry naturally presents itself:—Why is not the matter composing the sky within the sidereal system as well as beyond it? And the most reasonable theory to suggest as an answer seems to be that the sky is composed of the same gaseous elements from which the planets and stars have been evolved, and so we can not expect to find it within the space occupied by the stars, except as we find it solidified or condensed into planets or stars or nebulæ.

"The theory that the process of star making is going on every day is not only consistent with the law of evolution, but, if we reflect, we shall find it to be a necessary corollary of that law. It also receives material support from many observed facts which I need not mention. But that theory can not stand for a moment save upon the hypothesis that there exist, in space the material from which new stars can be evolved.

"Looking upon the sky as unorganized or unformed matter, what solemn and awe-inspiring thoughts crowd upon us! The workshop of the Almighty! The material for myriads of future stars lies there undisturbed. That which, ages hence, in God's own good time, shall, through His divine laws, become evolved into the material bodies of countless beings whose planetary abodes are not yet in embryo, there awaits his divine art and quickening breath. So did the elements of these bodies of ours,

ages upon ages ago, when, perhaps, intelligent creatures inhabiting older systems, looking hitherward upon the gaseous matter from which our solar system was afterward formed, asked themselves, 'What is the sky?'

"And is not the sky, thus considered, an indispensible fact without which creation past cannot be accounted for, nor creation future expected? Is it not essential to the best approved theory of material evolution that there should be an infinite store house of unused material existing outside of organized matter,.....raw material awaiting the hand of the divine Artificer to mould and fashion it into stars; the sidereal system's atmosphere, which, however much may be taken from it and added to the living world, must, by reason of the infinity of space which it fills, ever remain an envelope that will entirely reflect and conserve light, heat, and all the energies expended within the sidereal system."

We have made this long quotation that our readers may know the points which the author has sought to establish and his reasons in support of them given in his own language. It does not seem to us that the author has established his new theory. It does not follow that the sky is beyond the stars because it has color, for many phenomena covering large and small areas in the heavens, have color when they are known to be within two hundred miles of the Earth's surface. A very striking example of this is the display of Auroræ in northern latitudes. The varied color is sometimes striking, and yet, the stars shine through it all not usually with diminished lustre, but increased radiance. From this very fact physicists have strong reasons for thinking that the disturbed condition of the atmosphere in such electrical storms largely increases the twinkling of the stars and they look large and very bright.

It is also well known to observers that the stars are seen through the tails of comets even very near the densest parts of them without sensibly diminishing the light as it passes through these very rare masses of matter. If one thinks of the minute particles of matter that compose a comet's tail, as being probably hundreds of feet apart, it will be easy to see that the light of a star passing through such a medium as that could not possibly suffer any appreciable diminution though examined by the aid of high telescopic power.

Again, as one views the very faint stars by the aid of high optical power, he will notice, in the regions of the Galaxy that these stars, on the best nights, have many, many others apparently behind them that the eye can only catch glimpses of; yet

the practiced vision has some assurance that there are stars beyond those that can only be suggested by the faint light that fills those unknown depths far beyond. This faint star light is very suggestive in regard to the question whether or not light loses anything in traveling through the immense depths of our stellar universe. Every scholar knows the law of diminution of light as it passes through space from its source that it varies inversely as the square of the distance it travels. Now if the light of great star worlds has diminished so much in passing through space that the giant telescopes of the present day can only bring a glimmer of them to the human eye what shall we say of light that comes only from a gas that is very much further away, because by this new theory the sky is composed of gaseous matter which is situated beyond our stellar universe? The stars are great incandescent bodies radiating light with tremendous power. Gaseous bodies, if they shine by their own light are weak radiators in comparison with the stars. If we place the source of the light of the sky so far away, it is a very puzzling thing to know how its full, strong light can be conveyed through immeasurable spaces with results that out do light sources of much higher order.

It it is also claimed by the author of this new book that because the blue of the sky becomes deeper in hue when it is viewed from the tops of mountains that this fact supports the theory that the sky is beyond the stars.

During the summer of 1904, the writer was in the Rocky Mountains for astronomical purposes and observed there for a period of forty-eight days, in which there was opportunity to view the stars by the aid of three telescopes of apertures, respectively, four, five and eight inches. During this long period there were very few nights comparatively that were not fairly good for photographic work. The time was so chosen that we had two dark periods of the Moon and one light one between. The altitude of the observing station was 5000 feet above sea level. The condition and the color of the sky were carefully noticed, of course, and some simple tests were then made that should fix in mind the advantages of a position of that altitude and locality for successful work in stellar photography. The color of the sky was especially noticed, and as we had expected, it was of a deeper blue than we had commonly seen it at Goodsell Observatory whose altitude is less than 1000 feet above sea level. But that fact does not seem to us necessarily to favor the hypothesis of great distance. If it has any bearing at all on the question it

would seem to us to indicate exactly the opposite view; for if increasing altitude deepens the blue of the sky, i. e. tends to change the color to the violet, go far enough, and probably the violet will be lost and absence of all color will appear, and the stars would be seen where they are not quenched by the direct light of the Sun.

Another interesting fact that we noticed in those mountain observations was that we could see and count with the naked eye many more stars in a given area of the sky than we had ever been able to so observe at lower altitudes. This, we know, is the common experience of others in similar circumstances, but it shows that the depth of the atmosphere does have a veiling effect on the light of the stars whether the observer notices any color in the circumstances or not. The light blue veiling of the time of Indian summer, if not caused by smoke at that time of the year, so far as we know, has never been a hindrance to observation, but sometimes it appears when the atmosphere is comparatively dry and observation is better than the average. We can not say that this veiling is always either a help or a hindrance to favorable observing conditions, for we have not observations enough to point either way to a physical hypothesis. But so far as we do know we have not seen the hindrance on the point of color that is suggested would certainly appear if the blue of the sky was within the Earth's atmosphere.

Still another helpful inference may be drawn from mountain observations. In 1892, the writer was in the Rocky Mountains in the month of November at an altitude of 7000 feet above sea level. In looking to the south along the crest of the range thirty five lakes in the mountains were counted. The mountain peaks were lightly covered with snow, but the water in the lakes near by was not yet frozen over, and from all those many sheets of water the color was as blue as the clear sky above them. The contrast with the white of the mountain peaks was impressive and strikingly beautiful. When riding in a small steamer on one of those charming mountain lakes, though the color then seen was not so marked as that just described, the bluish tinge was observable, and yet the depths to which the eye could see was surprisingly great, chiefly because the mountain water is very clear, but apparently the bluish tinge in its depths did not hinder vision.

This far we have very briefly considered the principal arguments which the author has presented in support of his view of the source of the color of the sky, and the place where he infers that

its location is in relation to the sidereal universe. It is but fair to him to say that all the arguments presented tend, in his thought, only to raise a presumption in favor of his view, because he very well knows that such a question can not be settled by argument that is deduction in kind, and so absolutely true; but rather that what he is trying to show that it is more probable from the evidence at hand to believe that the sky, as we see it and know it, is at a distance beyond the starry universe.

Whatever bearing the views we have presented may have on the position of the sky in space and its color to intercept light that passes through it, it may have on helping to decide this question, it will readily be seen that we do not think that the author's views can rightly claim nearly the full force he claims for them. It rather seems to the writer, that in most particulars his arguments would apply equally well to a blue sky located in the regions of our terrestrial atmosphere. The arguments offered to support the theory that the illimitable regions beyond the stars is filled with gaseous material of which Suns and worlds are to be made sometime in the far off eons of time is incidentally pretty to think of and *possibly* it may all be true. We wish we knew *something* about that. If we look at the motions of the hundred stars near to our Sun which we do know just a little about, and see that these stars near us are moving in all possible directions in space with very different velocities and think that we do know scarcely anything about the motions of a hundred million other stars beyond these, because they are so far away, it would seem like a very difficult task to determine anything in regard to the condition of matter, (if there is any) beyond the starry system so called. Again as we have before said, look through the most powerful telescope in the world, and think that your eye sees beyond a sphere of stars that would count to more than one hundred million which are all Suns, like our own in some respect, pouring out floods of light in these vast depths of space continually, and yet our giant telescope only reveals them by faint glimmers that make us uncertain whether we do really specialize them as stars or not. If we still further think that these faint impressions of star light that now fall on the human eye have traveled through space, on their way to us, at the rate of 186000 miles per second, for one thousand, possibly two thousand years, we get some idea of what we really know of the conditions of matter in the interstellar spaces when we have tried to fathom them by the greatest power now available to human genius.

To frame a theory that will address itself promptly to modern scientific thought, one should have, as its basis, facts or relations that do not involve inherent physical improbability, at least; and if the claims of the theory can be subjected to physical tests, so much the better for the theory.

Evidently, our author thinks that his theory comes clearly within the conditions of the first part of the above criterion, or he would not claim so much for his proofs.

The real merits of this theme have not been touched upon at all, because we have not looked at it directly at all, but negatively for the purpose of testing the strength of arguments offered in support of the new theory. This part of the study must be deferred till another time.

SOME OF THE ASTRONOMICAL WORK OF LAST YEAR.*

I pass on now to a brief review of some recent advances in astronomy, among which I consider that the photographs of the Martian canals secured at the Lowell Observatory take a high place. The late Mr. Green, in his Presidential Address in 1897, predicted with great acuteness this result in a passage which I quote. After describing the cause of previous failures in planetary photography, viz., insufficient sensitiveness of plates and atmospheric disturbances, he said, "How then are we to escape from "these troubles?.....by making plates very much more sensitive, and, it may be added, by taking a considerable number of them, so that the most perfect of them might be selected. I have every confidence that this will be attained, and that we shall eventually possess photographic pictures of the planets as perfect as any that have been produced of the moon. Then will come the time to see not only the canals of Mars, but also the broad soft-shaded markings together with them." The recent Bulletin that described Mr. Lampland's success, stated that the difficulty of atmospheric blurring was overcome, as Mr. Green suggested, by taking a large number of exposures with an apparatus somewhat resembling the bioscope, but permitting exposures of eight seconds or thereabouts. Other features contributing to the success obtained were the use of a Wallace screen, and the diaphragming of the object glass to suit the atmospheric conditions.

The results are a very notable advance in planetary photogra-

* Extract from the address of A. C. D. Crommelin, President of the British Astronomical Association.

phy; nearly every print shows one or more canals, while the best of them show six or eight. I had the pleasure of meeting Professor Lowell a few weeks ago on his way across London, when he showed me the pick of his prints, on many of which the canals were clear and unmistakable, appearing as continuous narrow, slightly curved lines. These photographs did a great deal to strengthen my faith in the objective reality of the canals, which I had previously looked on as probable but not quite certain. The photographs even showed evidence of duplicity in one or two cases, though the only one on which I felt quite confident was the Lacus Ismenius, which appeared unmistakably as a pair of small dark spots. It does not follow that every case of apparent duplicity is real. The contrast theory advanced by M. Antoniadi seems quite capable of explaining a good many of them. According to this the interior of a dusky region on a brighter background seems brighter by contrast, while the edges seem darker, and hence the illusion of duplicity may readily be produced. I feel, however, pretty confident that in the case of Ismenius Lacus the duplicity was real, and Professor Lowell assured me that there were several other cases equally well marked. In addition to their testimony to the existence of the canals, it appears to me that these photographs should be utilized to improve our knowledge of the outlines and relative positions of the large dark markings which are shown with great distinctness. Mr. Green, in the address from which I have already quoted, said that some observers made these large markings altogether subservient to the faint streaks. The photographs do not err in this respect, but give to each their proper importance. They can be studied and measured in a much more deliberate manner than is possible at the telescope, and they are free from the large errors of position to which even the best draughtsmen are liable, as will be seen at once on comparing simultaneous drawings by different observers. Such questions as the alleged changes in the outlines of the Syrtis Major should be settled by photography, also possibly changes in the relative brightness of different regions. I emphasize these points since Professor Lowell himself did not appear to consider that the value of the photographs extended beyond the canals, but in my opinion they will serve to put the map of the planet on an absolutely secure foundation. Professor Lowell has also made a new determination of the position of Mars' axis, combining his own measures with those of Schiaparelli, Lohse, and Cerulli. The most striking point is the reduction in the obliquity of the Martian equator to the orbit. The value

formerly adopted was 25° 13′, the new value is 23° 59′, which is very little greater than our own obliquity, 23° 27′.

I pass on now to the remarkable discoveries in the satellite world, which have produced quite a revolution in many of our ideas. The older satellites have very regular orbits with small eccentricities, and, in most cases, nearly coincident with the equatorial planes of their primaries.

In the case of our own Moon, which we must regard as a distant satellite relatively to the size, of its primary, the tendency is to coincidence with the primary's orbit plane, and we see a similar tendency in the case of Iapetus, which is by far the most distant of the older satellites. While all the inner satellites of Saturn show a close accordance with the equatorial plane of their primary, Iapetus deviates from this so as to be nearly midway between it and the orbit plane. We see here, as it were, an indecisive battle between the action of the equatorial protuberance and the perturbing action of the Sun; for all the inner satellites the former prevails, while the lately discovered Phoebe, which lies far outside Iapetus, admits the superiority of the solar action, and like our own Moon moves near the plane of its primary's orbit.

So far Phoebe is acting as we might have reasonably expected, but the astonishing fact of its retrograde motion, in direct opposition to every other movement in the Saturnian system, is indeed calculated to take away our breath. For the moment we provisionally accepted Professor Pickering's hypothesis that solar tides had reversed the direction of Saturn's rotation subsequently to Phœbe's birth, but before that of the inner satellites. He predicted that all very distant satellites would share this retrograde movement, an anticipation which has been very quickly falsified since the two new Jovian satellites have been found to move *directly*. There is just one escape for the Pickering hypothesis, and that is that the solar tides were so much more potent on Jupiter, owing to the greater size of the primary and the smaller distance from the Sun, that reversal took place before any satellites were born. But, however that may be, it can scarcely be an accident that we meet with retrograde motion in the three outermost families of the solar system, and in these alone. Furthermore, the retrograde features become more pronounced as we proceed outwards. In Saturn's large family Phœbe is like a single truant child. The plane of motion of the Uranian family is so nearly at right angles to the orbit plane that a shift of 9° would convert the motion from retrograde to direct;

hence we may look on it as almost in a neutral position. But in the case of Neptune there is little doubt that the rotatory movement is almost counter to the orbital movement. These facts certainly seem to form a good *a priori* case for the thesis that the primitive direction of rotation of the matter that subsequently formed the planets was retrograde, and that the Sun has in some way reversed this motion for all the nearer planets. The exact mode of this action is still a mystery, but I commend the problem to our members as a most attractive field for speculation and research.

In proceeding to review the three satellite discoveries of the present year, perhaps I may be allowed to enter a mild protest against the tantalizing delay in circulating full information. In each case we had to wait several months after the first meagre telegraphic announcement before we were put in full possession of the facts. In the case of the sixth satellite of Jupiter it is quite probable that several observations would have been obtained in Europe last January if enough information had been transmitted to enable a fairly good ephemeris to be formed. There was further a considerable amount of time and energy wasted in examining whether the asteroid found near Jupiter by Dr. Wolf was identical with the satellite—a question which would have been settled at once if the December positions of the latter had been available. I hope that future discoverers will treat the astronomical world more generously, and not repeat a policy which resembles that pursued by the mediæval astronomers, who announced new discoveries in anagrams, and withheld the key till some months or years later.

However, after this little grumble, I wish to extend my heartiest congratulations to Mr. Perrine on his most interesting discoveries which were in no sense accidental, but the well earned reward of a deliberate search, undertaken doubtless in consequence of the discovery of Phœbe with which they invite comparison. The points of resemblance are the minute size, the great distance from their primaries, the highly eccentric orbits. But there are many striking differences. Phœbe, as we have seen, departs from Saturn's equator towards its orbit plane, with which it is nearly coincident. In Jupiter's case the equator and orbit plane almost coalesce, so that apparently there is no cause to make a satellite deviate from the common plane. And yet we find quite unexpectedly a very high inclination of about 30° in each case, though the orbit planes of VI. and VII. are not coincident, but make a large angle with each other. Another curious point is that their

periods are so nearly equal that it is not yet certain which is the nearest to Jupiter. Dr. Ross gives 251½ days as the period of VI., while I have found 265 days as that of VII. The motion of both satellites is direct, which, as I remarked above, is rather a disappointment. In the presence of these anomalies, we experience the same feelings of bewilderment that astronomers felt a century ago, when Ceres and Pallas were discovered with their large inclination and eccentricities, and their almost identical periods. It seems, indeed a fair analogy to compare the older satellites with the major planets of our system, and to suppose that this mine is now exhausted, and that those which remain are "asteroid satellites" in which all kinds of anomalies may be expected. We may then couple the problem of explaining the origin of VI. and VII. with the asteroid problem which still remains without a solution, except the explosion hypothesis, which at one time looked promising, but is now generally discredited.*

Some have supposed that Phoebe and the two new Jovian satellites are not true children of their primaries, but recent captures; it seems, however, to be generally accepted among mathematicians that a planet cannot capture a body so as to make it revolve in a closed path about itself, though it may perform this service for some third body, such as the Sun. I cannot ascertain that any one has given a rigorous demonstration of this proposition, but it commends itself to common sense, and is probably true in all cases that are in the least likely to arise. In this case the capture hypothesis would require that VI. and VII. had been captured by one of Jupiter's larger satellites, but at present their orbits do not approach sufficiently nearly to make this possible. We should have to assume that they had formerly very large eccentricities, which have been reduced by perturbations, but I think that, till the advocates of the capture theory have demonstrated the possibility of such changes, we are justified in setting the theory aside.

Even if we are baffled in our search for an explanation of their anomalous orbits, we must admit that the new satellites add a great deal of interest and romance to the Jovian system. We must picture two very minute orbs, probably one 100 miles, the other 30 miles in diameter, revolving in solitude seven millions of miles from Jupiter, from which they would appear as tiny stars, scarcely visible to the naked eye; their distance is 30 times that

* The President here exhibited and described a model he had made to illustrate the orbits of Jupiter's satellites.

of the Moon from the earth, and their period is 500 times that of Satellite V., a disparity nearly as great as that between Mercury and Neptune.

This seems to be an appropriate place to briefly review some satellite work of a different charcter that has been done during the year. A series of photographs of Neptune's satellite extending over the last four years have been obtained at Greenwich, and have recently been discussed by Mr. Dyson and Mr. Edney. It has been known for some time that the plane of the satellite's orbit is not stationary, but shows a fairly rapid shift. It was pointed out by Tisserand and Newcomb that the cause is almost certainly the action of the equatorial protuberance of Neptune, which must, therefore, be inclined at a considerable angle to the satellite's orbit. If we plot down on a map the observed positions of the pole of the orbit at different dates, they should lie on a small circle whose center is the pole of Neptune's equator. Till the recent photographs were taken the path of the pole of the orbit was scarcely distinguishable from a straight line, but it now begins to show decided signs of curvature, so that we can make an approximation to the center of motion.

It thus appears that the pole of Neptune's equator lies in R. A. $19^h\ 30^m$, North Dec. 42°, and that the obliquity of Neptune's equator to its orbit is about 28°, or not very much greater than the value for the earth. The satellite's orbit is inclined about 20° to the equator of Neptune. These values are given only as rough approximations, but they are very interesting as giving us for the first time a clue to the position of Neptune's axis. Twenty years more of good observations should settle the question with considerable precision.

Some calculations by the late M. Tisserand enable us to deduce that if the angle between the orbit and equator is 20°, then Neptune's period of rotation is 19 hours, and his polar compression $\frac{1}{14}$, a quantity too small to detect by direct observation. We thus see that the observation of satellites may indirectly lead to most interesting information about their primaries. For example, it is practically certain that the equator of Uranus makes only a very small angle with the satellite planes, from the fact that all four satellites have a common plane, and that no shift of the node can be detected. The inner satellite would show a decided shift, if the angle between the two planes were as great as 10°.

There is one other point on which I should like to say a word, and that is the great attention that has been given in recent

years to the study of motion in the line of sight by the spectroscopic method. It has been applied to the solar system and the stellar heavens; attempts have been made to obtain by its aid the rotation periods of the Sun, Venus, and Uranus, though it must be confessed that the problem is such a delicate one, from the very slow velocities in question, that we cannot give very much weight to the results obtained; thus M. Belopolsky found a short period for the rotation of Venus, while Professor Lowell's results favor a period of 255 days. But in the stellar heavens materials are being rapidly accumulated, which will in a few years place our knowledge of the structure and motion of the sidereal system on a much firmer basis, and enable us to deduce the mean distance of stars of various magnitudes by comparing their linear velocity with their apparent proper motion. The spectroscope has also revealed to us the existence of a great number of most interesting binaries, with periods of only a few days, and has enabled us to measure the distance from us of a few binaries whose period is short and orbit well-determined. In particular, the astronomers of the Lick Observatory have deduced the distance of α Centauri, their result agreeing perfectly with that given by Sir David Gill from measures with the Cape heliometer.

It was long ago pointed out that the change in a star's motion during the year produced by the earth's revolution would theoretically enable us to determine the distance of the Sun by the spectroscope. Many, however, thought that the method would be far too rough for the purpose. Nevertheless, within the last few days a determination of the Sun's distance by this method has been published, which is one half a million miles smaller than the generally accepted value. It is true that for the moment we take this rather as a verification of the spectroscopic method than the distance, but it illustrates the possibilities of the method, and leads to the hope that the combined results of several years may give a determination of the Sun's distance entitled to considerable weight.

THE NINTH AND TENTH SATELLITES OF SATURN.*

WILLIAM H. PICKERING.

When the photographs of Saturn, taken with the Bruce telescope in 1904, reached Cambridge, it was found that the images

* Annals of Harvard College Observatory Vol. LIII, No. IX.

of Phoebe shown upon many of them were clearer and more distinct than those found upon any of the earlier plates. It seemed desirable, therefore, to examine them carefully with the object of searching for still fainter satellites. A hasty examination made early in September showed some suspicious objects which were not stars, close to Saturn, upon several of the better plates. In the plates taken after August fifth a small screen was employed to diminish the light of Saturn in order to obtain a smaller image of it. Since this screen would completely hide any object as close to Saturn as the suspected satellite, only the earlier plates could be employed in the search. Two of these, A6703 and A6798, were at once rejected, the first because it showed only the brighter stars, and the second because it was badly broken and the film injured. The remaining twenty plates, briefly described in Table I, pp. 86 and 87 of the present volume, were set aside for further study. Work upon Nos. V and VII of this volume occupied my time for several months, and it was not until towards the end of March of the present year that I was again able to take up the search for the tenth satellite.

The difficulties that presented themselves were considerable, first because the suspected satellite was clearly fainter than most of the images of Phoebe, secondly because the immediate vicinity of a bright object like Saturn often presents markings and defects that are not found at a greater distance from it, and thirdly, because there seemed to be at least two of these objects, of about equal brightness, between which and the occasional defects it was sometimes difficult to discriminate. Merely to find objects on three or four plates, which were not found upon others, and through whose positions a probable orbit could be passed, was not sufficient, therefore, to settle the question of the reality of the satellite. A careful study had to be made of each of the twenty plates, maps drawn of all stars down to the eighteenth magnitude in the immediate vicinity of the suspected satellites, and an orbit constructed which would account for the satellite on as many of the plates as possible and also show why it did not appear on the remaining plates. It was not until April 28 that I felt sufficient confidence in my results to be ready to announce them, and accordingly Bulletin 189 was then issued, and telegrams sent to the leading observatories.

A name has been selected from among those of the sisters of Saturn, as in the case of Phoebe, and it has been decided to call the new satellite Themis.

I had hardly begun my examination of the plates before an un-

expected difficulty arose. On the earlier plates, where Phoebe was fairly well seen, images of the new satellite were found without difficulty, but on the later plates, where Phoebe was very conspicuous, the new satellite could not be found at all.

The most obvious explanation was that one or the other of the satellites was variable. On account of its short period, the later plates should have shown Themis in various parts of its orbit, but on none of them was it to be seen. A study was then made of the images of the other satellites, especially of Phoebe and Hyperion, since they were the faintest, and it was soon noticed that on all the later plates the images were drawn out into trails, owing to defective following of the telescope, while in most of the earlier plates the images of the satellites appeared as round dots. In this manner the plates were divided into two distinct classes; one, consisting of thirteen plates in which the trails of the satellites little if any exceeded 0.10 millimeters in length, and the other class consisting of seven plates, in none of which the trails were less than 0.25 millimeters long. On none of these seven plates could a satisfactory image of Themis be found. They were accordingly rejected for the purposes of the present investigation.

In No. V of this volume, page 98, it was pointed out that on certain plates taken this past year, where the satellites trailed, Phoebe was unusually distinct. This result was there attributed to the possible use of a hydrochinon developer. It now appears that while this developer may have been used with some of these plates, most of them were developed with rodinol, so that this explanation cannot be accepted. Three plates were taken in September, 1898, where Phoebe appears as a trail. Some doubt was formerly felt about accepting them, partly because the images were so bright, considering that they were trails, and partly because they did not seem to be in the right place. The latter difficulty has now been overcome by Dr. Ross, who in No. VI of this volume shows that a slight change in the assumed eccentricity and period will bring these plates into accordance with the others. The plates of 1898 and also those of 1904 were taken just before superior conjunction of the satellite with its primary.

Four plates were taken in August, 1899. Although apparently of excellent quality, no satisfactory images of Phoebe could be found upon them. They are described in more detail on page 88. On the plate taken in October, 1900, the image of Phoebe is surprisingly faint. The plate was rejected in the earlier examination, but Phoebe was subsequently found upon it, as described in No.

V. The plates of 1899 and 1900 were taken just before inferior conjunction of the satellite with its primary.

These facts lead one to suspect that, like Iapetus, Phoebe is a variable satellite, dark in one portion of its orbit and bright in another. Like Iapetus, therefore, it probably always presents the same face to Saturn. Its range of brightness appears to be about 1.5 magnitudes. The range of brightness exhibited by Iapetus, according to the latest measurements made by Professor Wendell, amounts to 1.7 magnitudes. So large a range can only be due to the fact that one side is very bright, and the other extremely dark, the boundary between the two being well defined, and each area occupying nearly a full hemisphere. The only time that Phoebe has ever been seen was at the Yerkes Observatory, when it was detected by Professor Turner and Professor Barnard. This was on August 8, 1904, which was very near the time of its maximum brilliancy. It was then but just visible with the closest scrutiny. It is probable that at other times it can only be detected by photography.

If the Yerkes telescope absorbed no more light than smaller instruments, it should be capable of showing a star of magnitude 17.0. Allowing half a magnitude for absorption, we may say that at maximum brilliancy Phoebe is probably of magnitude 16.5. When at minimum brilliancy it must then be of about magnitude 18.0. Its mean brilliancy is therefore 17.2, which is 0.8 brighter than what I have adopted as the limit of the Bruce telescope, with an exposure of two hours.

Themis, on the other hand, seems to show no evidence of variability so far, and is of about magnitude 17.5, or a little fainter than the mean brightness of Phoebe. It must therefore remain invisible to the human eye, until larger telescopes capable of showing it are built.

The linear diameter of Themis can only be determined on the assumption that its albedo is the same as that of some other body of known size and brightness. The best object for this purpose seems to be Saturn's largest satellite, Titan, the only one presenting a definite disk in the telescope. According to the best micrometric measurements, the diameter of Titan seems to be about 2300 miles. Professor Wendell's recent observations indicate that at a distance of ten astronomical units, Saturn also being at a distance of ten units from the Sun, the magnitude of Titan would be 8.46, or about 9.0 magnitudes brighter than Themis. This would give for Themis a diameter of 38 miles. Similarly the diameter of Phoebe would be 42 miles.

If Themis is 3.5 magnitudes fainter than Hyperion, it will give just one twenty-fifth as much light. For comparison with terrestrial dimensions we may say that to see a sphere 40 miles in diameter at a distance of 900,000,000 miles would be equivalent to seeing a ball eight inches in diameter at a distance of 3000 miles. It must also be remembered that at the distance of Saturn the intensity of sunlight is but one one-hundredth as great as it is upon the Earth, so that a ball rather less than one inch in diameter at a distance of 3000 miles would reflect as much light to us as Phoebe or Themis. * * * * * * * *

Figure 1 represents the orbit of Themis, as projected on the sky. It is oriented with north at the top, and is on a scale of 2.5 centimeters to the minute of arc, the orbit being represented at a distance of 10 astronomical units. At this distance 1 minute is equal to 270,000 miles, or 434,000 kilometers. On the outside

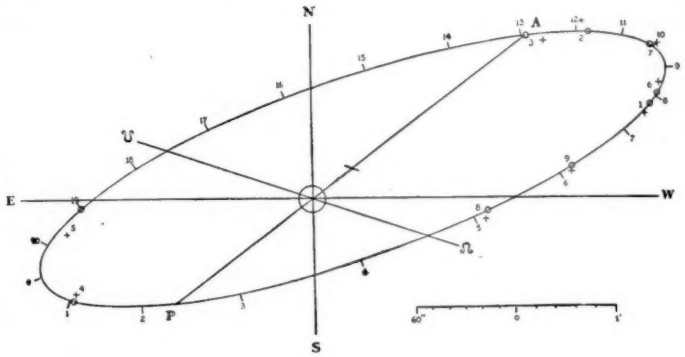

FIGURE 1.

of the orbit is marked the number of days that have elapsed since eastern elongation. On the inside are given the numbers of the nine observations. The crosses indicate the observed, and the circles the corresponding computed places of the satellite. On the major axis, PA, is shown the ball of Saturn drawn to scale, and also the centre of the orbit.

Two of the elements, namely the eccentricity and period, are given directly by the ellipse, and the semi-major axis is computed from the period. The epoch of the passage of eastern elongation has been already given. The three remaining elements, the inclination, the longitude of the ascending node, and the longitude of the perisaturnium, must be computed. These might be referred

as in the case of a double star to the plane passing through the star and the observer, and cutting the celestial sphere parallel to the equator. These results could then be reduced to the plane of the ecliptic. A much simpler plan, however, and one amply accurate enough for the results in hand has been adopted. It consists in treating the orbit as a circle, with Saturn placed to one side of its centre. Although the eccentricity is large, namely 0.23, the difference between the major and minor axes of the real ellipse is only three per cent. Increased accuracy is obtained by employing different values for the semi-diameter of the orbit depending on the location of the point whose position is to be determined. These semi-diameters are readily obtained by interpolation.

In Figure 2, $E\,W$ is the declination circle passing through Saturn. $P\,A$ is the major diameter of the true ellipse, and $B\,D$ its minor diameter. This latter is obtained by passing a chord through any point in the major diameter except the centre, the chord being so oriented that it shall be bisected. The minor diameter

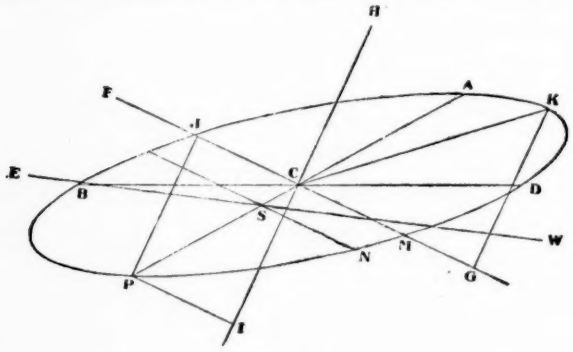

FIGURE 2.

s drawn through the centre, parallel to this chord. $F\,G$ is a line drawn parallel to the ecliptic, and $H\,I$ a line perpendicular to it. $S\,N$ is drawn parallel to $C\,M$, N bearing the same direction on the celestial sphere from S that M does from C. F is, therefore, the perisaturnium, and N the ascending node. $P\,I$ is drawn perpendicular to $H\,I$, and $P\,J$ and $K\,G$ to $F\,G$, $K\,G$ being the maximum ordinate of the ellipse. The date to which the positions of the satellite in its orbit were corrected for the motion of Saturn was 1904, July 12. At this time the longitude of Saturn as seen from the Earth was 319°.7 and its latitude $-$ 1°.2.

Let r be the semi-diameter of the ellipse, then $\frac{K\,G}{r}$ gives the sine

of the angle of the inclination. $K G$ equals 2′.13, and r in this portion of the orbit is 3′.32. The inclination, 39°.8, corrected for the latitude of Saturn into the sine of the longitude of the point K, or — 0°.8, is 39°.1. To determine the longitude of the ascending node, we take the angle whose sine is $\frac{C M}{r}$ where $C M$ equals 1′.39, and r in this portion of the orbit 3′.29. The result corrected for the longitude of Saturn is 164°.7. We next determine the latitude and longitude of the point P, from C as a centre. The latitude is given by the distance $P J$, 1′.84, the longitude by $P I$, 1′.27. The radius r equals the major semi-diameter, 3′.357. The latitude of P is found to be — 33°.2, the longitude, corrected for that of Saturn, 112°.8. The arc $P M$, determined by a spherical triangle, is 58°.9, and the longitude of the perisaturnium from the node, $M D A B P$, 301°.1.

Summarizing our results we obtain the following values for the elements of the orbit of Themis.

The semi-major axis at a distance of ten astronomical units measures 3′.357, or 201″.4. This corresponds to a distance of 0.00974 astronomical units, 906,000 miles, or 1,457,000 kilometers.

The eccentricity is 0.23, which is the sine of 13°.3.

The inclination to the ecliptic is 39°.1.

The longitude of the ascending node is 164°.7.

The longitude of the perisaturnium from the node is 301°.1.

The epoch at which the satellite passed perisaturnium was 1904, April 11.5 G. M. T., or Julian Day, 2,416,582.5.

The period is 20.85 days, which corresponds to a mean daily motion of 17°.27.

While the values of these elements were determined by the simplest methods, after the ellipse was once found, yet it is believed they are amply accurate enough for our present requirements. It is possible that a further adjustment of the ellipse might lead to some slight changes, involving a decrease in the eccentricity of 0.015, and an increase in the inclination, and longitude of the ascending node, by 1°.4 and 1°.9 respectively. These changes, however, would be so slight that it was not thought worth while to make them until further observations had been secured. This readjustment of the ellipse would be rendered probable, should the image found on Plate A 6742 prove to be due to a defect, or to another satellite.

The semi-major axis of the orbit, when Saturn is at its mean distance, is 211″.2, or only 2″.1 less than that of Hyperion. The

inclination of the orbit exceeds by 10° that of the orbits of the other inner satellites of Saturn. Its eccentricity is greater than that of any other known satellite, being exceeded by only a few of the asteroids. Its maximum distance from Saturn is 1,115,000 miles, its minimum distance 698.000 miles. Its distance from Saturn being intermediate, and but little different from that of Titan and Hyperion, its eccentricity causes it to be sometimes 61,000 miles inside of the mean place of Titan, and sometimes 198,000 miles outside of the mean place of Hyperion. At aposaturnium it even exceeds the maximum distance of Hyperion by as much as 88,000 miles. The relation of the three orbits at the present time is exhibited in Figure 3, where that of Themis

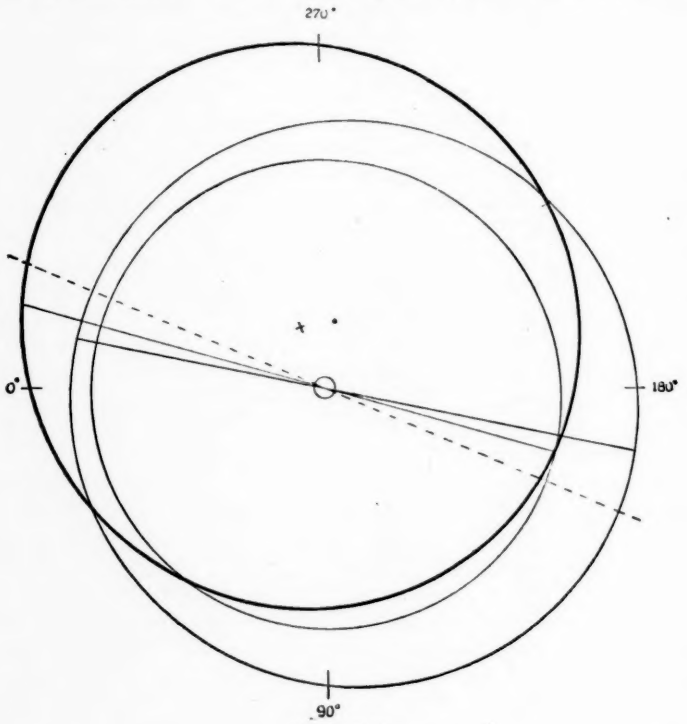

FIGURE 3.

is projected into the plane of the orbit Titan. The orbit of Hyperion very nearly coincides with this plane. The orbit of Themis is represented by the heavy line, the two diameters indicate the location of the nodes of Titan and Themis, while the

dotted line indicates the intersection of the planes of their orbits.

The five inner satellites of Saturn all move in nearly circular paths, while the orbits of the outer five are all more or less eccentric. The line of apsides of Titan advances half a degree annually, that of Hyperion retrogrades eighteen degrees in the same time. This is due to three facts, first that the two orbits lie nearly in the same plane, second that near perisaturnium the orbit of Hyperion lies very near that of Titan, and third that three revolutions of Hyperion are performed in almost exactly the same time as four of Titan. The difference is but $1^h\ 09^m$ in sixty-four days, and since Hyperion always falls behindhand owing to this cause it is pulled towards Titan a little earlier each third revolution, and accordingly its apsides retrograde. If its mean distance from Saturn had been 0″.1 less, so that it could have gone a little faster, its apsides would have advanced instead of retrograding.

When the perisaturnium of Hyperion and the aposaturnium of Titan are in the same longitude, which occurs once in every twenty years, the distance between them is reduced to 25,000 miles. The present minimum distance between these satellites is 64,000 miles. Since none of the three above mentioned relations hold between the orbits of Titan and Themis, it is obvious that no such effect will be observed in the case of the latter satellite.

The nodes of all the satellites except Iapetus and Phoebe lie within five degrees of one another, and since the orbits of all save Iapetus, Phoebe, and Themis are practically coincident with the plane of the planet's rings and equator, it is clear that in order to maintain this relation all their nodes must possess the same average rate of recession. The nodes of the orbit of Titan have retrograded 7′ in the past forty years. This would indicate a period of about 120,000 years for the precession of the equinoxes of Saturn.

It may at first seem a little strange that, unlike all its neighbors, the inclination of the orbit of Themis should fail to coincide with that of the rings. The explanation seems to be that at the ascending node, shown on the right in Figure 3, the orbit passes very close to that of Titan. If the longitude of the node was identical with that of the node of Titan, namely 168°.3; Themis would pass but 7000 miles outside of its huge neighbor. If the longitude of the node of Themis were 167°.3, the two satellites might collide. With the longitude of the node at its present figure, 164°.7, the satellites come nearest together in longitude 160°, where Themis is inside of, and north of the orbit of Titan,

the distance between them being 13,000 miles. At this distance, Titan would present a disk about 10° in diameter, or nearly twice as great as that of Saturn. The two satellites are in the same plane, indicated by a dotted line, when in longitude 157°, their distance at that time being 16,000 miles.

If the nodes of Themis retrograde at the same average rate as those of Titan, which is undoubtedly the case, the closeness of the approach of the two bodies must depend mainly on the motion of their apsides. On account of the high eccentricity of its orbit this would be chiefly controlled by the motion of the apsides of Themis. If its apsides are advancing, of which there can be little question, it must have approached nearest to Titan at some time in the very recent past. The orbit is still in a very critical position. It was probably the avoidance of this collision which threw the orbit out of the plane of the planet's ring. As time goes on the attraction of the equatorial expansion of Saturn will tend to bring it back into that plane, only to be again ejected from it by Titan, in time to avoid a future catastrophe.

The fact that Themis has so far avoided collision or capture by Titan should give us a maximum value for the mass of the latter, and it is certain that the perturbations which may in the future be observed will lead to a still more accurate determination of this quantity.

In $271^d.07$ Titan makes 17 revolutions, and in $271^d.05$ Themis should make 13, the results being, therefore, so nearly commensurable that it is impossible to tell whether they are exactly so, or not. The Plate A 6749 was one of those taken when the disks of Titan and Themis were superposed. Computation shows that they were only 0.30 millimeters apart at that time, and unlike the other plates, it appears that on this one the satellites were really very near together. A few hours earlier the distance between them must have been about 40,000 miles. Another close approach took place in 1905, February $20^d.7$ G. M. T., and still another should occur in 1905, November $18^d.8$. Since the passage of Titan within this distance of Hyperion is more than sufficient to shift the perisaturnium of the latter's orbit through an angle of 3°, it is possible that an appreciable effect may be produced upon the orbit of Themis.

If further observations confirm the slight increase in the longitude of the node suggested upon p. 20, this will bring the orbits of Titan and Themis into yet closer relations, which will be made still more intimate by the suggested changes in the eccentricity and inclination. It may indeed prove that the avoidance of a

collision or a capture under the present circumstances is secured only by the exact commensurability of their periods of revolution.

THE LUNAR CYCLE.*

R. W. McFARLAND.

FOR POPULAR ASTRONOMY.

This is the celebrated period known from the fifth century B. C. —a period of 19 years, after which the new and full moons tend roughly to occur about the same days of the month as in the preceding cycle. The particular year of the cycle is called the Golden Number, and is given in the almanacs. It is brought forward now by reason of statements made by the authors of different text-books on astronomy:—statements entirely too positive; and made without any attempt to prove their correctness. One writer says, "At the end of nineteen years, the new and full moon recur again on the same days of the year, and at the same time of the day within two hours."

If one will take the trouble to compare the dates nineteen years apart, using the Nautical Almanac, he will find a very different result. Compare 1881 and 1900. In January of the latter year, the new moon was over a whole day too late; and for the next four months, varied from 23 to 17 hours. Then were four leap years in that period. Compare 1860 with 1879, where there are five leap years. The new moon in January and February 1879, occur over half a day too soon. For eight of the remaining ten months, the discrepancy raises from a half to a whole day too late. This want of coincidence depends chiefly on the changing eccentricity of the moon's orbit, and the longitude of the perigee; both causes being apparently overlooked by the writers, who are thus led to make assertions which are not in accordance with the facts.

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* The substance of this note was written as a part of the article "Miscellany," printed in the December number. In transcribing for the press these paragraphs were accidentally omitted, but the error was not noticed till too late to make the correction. R. W. McF.

OBSERVATIONS OF THE SOLAR ECLIPSE OF AUGUST 30, 1905, AT SFAX, TUNIS, AFRICA.*

G. BIGOURDAN.

Photographs of the Inner Corona. Our principal instrument was a horizontal telescope of ten metres focus and 0.m20 aperture, placed before a mirror mounted as a coelestat. It was made by Monsieur Mailhat and was intended to give coronal photographs on a large scale, showing the relations between the details of the interior corona and the corresponding points of the solar surface.

This apparatus operated by M. Dehalu assisted by M. Gorissen, furnished two photographs showing numerous details of the inner corona. It was arranged to furnish a larger number of plates; but the second plate placed obliquely no doubt, did not free itself and thus stopped the others.

The two plates obtained, like all those which had been prepared, have upon them a scale of intensity† which enables us to estimate the relative brightness of the different parts of the inner corona.

Monochromatic Photography of the Corona.—This photograph was obtained by means of a very luminous objective of four lenses, with a focus of about 0.m95, and aperture of 0.m15, and by placing before the plate a green screen which stopped the spectral radiations except those in the neighborhood of λ 530.

This apparatus, managed by Messieurs J. Eysséric and P. Heitz, was supported by a parallactic mounting run by clock-work. The exposure was prolonged during nearly the entire period of totality. The plate obtained shows the corona to about 30′ from the lunar edge; besides it presents two secondary images produced, doubtless, by some interior reflection which had not revealed itself previously. The plate used had been backed with one of the most efficacious anti-halos.

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* The above is an extract from a résumé of the observation made at Sfax, Tunis, in Africa, during the total solar eclipse on August 30, 1905, by G. Bigourdan member of the Institute and of the Bureau of Longitudes of France. Translated from the Bulletin of the Belgian Society of Astronomy, for POPULAR ASTRONOMY by Miss I. Watson, Professor of Modern Languages in Carleton College, Northfield Minn.

† This scale of intensity was obtained by exposing to a light of known intensity, and with increasing exposures, a series of little square areas on one edge of the plate. The comparison light used is that of acetylene burning in a lamp of the system of our colleague, Monsieur Violle, who kindly loaned me one of his lamps.

Spectroscopy.—We had two slit spectrographs each one with two prisms and producing a deviation of 90°. The collector of light had a focal length about $0^m.80$ and an aperture of $0^m.15$. The slits were long enough to reach considerably beyond the Sun on either side, in such a way as to obtain the composition of the coronal light at four points, nearly corresponding to the equator and the axis of the Sun.

These two instruments, placed on the same mounting as the preceding one, were also operated by MM. J. Eysséric & Heitz.

Ocular Photometry.—I determined the intensity of the coronal light by comparing it with that of a little electric lamp, by means of a Lummer photometer which M. Violle kindly loaned us. This little lamp, fed by a current of 2.2 volts, had to be placed at $0.^m63$ in order to produce a brilliancy equal to that of the corona.

When laboratory experiments shall have given us the intensity of the electric lamp in current photometric units, we shall then have the intensity of the corona expressed in the same terms.

Photographic Photometry.—A special apparatus with continuous register, produced on three photographic plates six bands corresponding to as many points of the solar vertical; these bands will enable one to determine at each instant the intensity of the light coming from each one of these six points. This apparatus, constructed only of wood, was rather difficult to manage; nevertheless MM. Genestous & Kervahut succeeded in making it work very regularly.

The Influence of the Passing of the Moon's Shadow on the magnetic condition of the Earth.—To help to make this influence evident we had established at Sfax a temporary magnetic station, including the three usual registering instruments: The declinometer, the balance and the magnetometer. It is well known that a very important condition for making evident slight magnetic variations, is that the instruments be placed within shelter from changes of temperature. What we have said about the nature of the soil where the French city of Sfax is built (fine sand, dust etc.) will explain why cellars are very rare. After some hunting we found a site almost perfect in the basement of a theatre which M. Gau kindly placed at our disposal.

The observations, organized by M. Dehalu, showed no remarkable magnetic disturbance except the day before the eclipse. In order to make definite statements about the influence of the eclipse, it is necessary to compare the curves of August 30, with those obtained before and after; but at present we can say that at Sfax this influence was very small.

M. Dehalu also determined at Sfax the absolute value of the magnetic elements.

Meteorology and Actinometry.—As soon as we reached Sfax we set up our registering meteorological instruments, some of which had been loaned us by M. J. Richard, the well known constructor.

To these observations were added, during the period near the eclipse, actinometric observations by direct reading, made by M. Gustave Eysséric: these readings were so near to one another as to make graphic representation possible; and this representation gives clear proof both of the influence of the clouds which ridged the sky on August 30, and of the influence of the eclipse itself.

Drawings of the Corona by the Naked Eye.—Two of these drawings were sent us by M. Bursaux; they were made at Maknassy by MM. Aussel & Teste, and it will be interesting to compare them with the representations of the corona furnished by photography.

Observation of Shadow Bands. This phenomenon, one of the most striking which accompany eclipses of the Sun, was observed this time in many places at Sfax or its environs, and by a large number of observers. Generally, they were sinuous and waning bands nearly parallel, often directed toward the Sun and changing their place perpendicularly to their direction with the average speed of a man walking. In the preceding eclipses I had not had the opportunity of observing these bands, and perhaps they would have escaped me again this time if another observer had not called my attention to them, for I was trying to observe the second contact. In the brief moment that I spent examining these shadows they made on the sand the appearance of shadows caused by a light smoke and with about the same regularity. We have been able to collect numerous observations of this interesting phenomenon and they will be discussed later.

Obscurity of the Eclipse. Visibility of the Stars.—The duration of totality ($3^m\ 30^s$) was much longer this time than in the eclipse of May 1900 ($1^m\ 15^s$) yet people agree in saying that the obscurity was not so great on the 30th of last August as in 1900; such is the opinion of our co-laborer M. Heitz, who operated nearly the same instruments during the two eclipses, and who could examine the sky at leisure during totality.

The stars which were visible to the naked eye are Venus, Mercury and Regulus; still a fourth one seems to have been seen for an instant by observers whom M. Jornier had specially charged

to watch the visibility of the stars.

Various Observations.—Animals were influenced as is usual at the approach of the eclipse; the birds, pigeons for instance, went to roost; the bats came out, etc.

Men were also affected, and trustworthy witnesses have told us of one locality in the neighborhood of Sfax where five women out of ten fainted with terror at the approach of totality.

THE FIELD OF POPULAR ASTRONOMY.

W. W. PAYNE.

We have studied long and patiently to know how to make this magazine fill the place open to it most largely and most effectively. We have tried coöperation in the responsibility of editorial work, and then the burden largely came back on ourselves, because free assistance of this kind usually has responsibility that is imperative in some other way. We have no reason to complain of the lack of aid or support from others interested in such work, because their help for more than twenty years has been generous and varied, so that no one has complained, in any marked way, even when it was very difficult to keep the standard of this private undertaking up to as high a mark as it ought to maintain in view of the good work it might do if so managed uniformly.

More than a score of years ago, this work was begun, believing that if we tried to help others who then needed the same kind of aid in the study of astronomy that we most earnestly desired for ourselves, we would find sources of aid from scholars in science all over this land that easily could and generously would remember such an enterprise favorably. In this we have not been disappointed, but have been supported beyond our own expectations, in carrying a financial burden that involves hundreds of dollars of expenditure every month, the great part of which must be paid in advance to secure the cheapest and best professional and skilled service needed for the publication.

When we say this, it may not be clear to all readers how it is that we have increased our subscription price for the future. To answer this, but a moment's reflection will be necessary. The wave of increased wages for skilled labor that has swept over this country within the last two years has made the cost of raw material, labor and living fully thirty per cent greater for salaried persons and publications with fixed charges for maintenance than was the case only quite recently. Hence to relate our work to

present conditions in the same way it was formerly this change in price seemed to us both necessary and reasonable.

Furthermore, the need of enlarging our space, somewhat, to give variety, and a fuller representation of the different branches of astronomy as they are now going on seemed to us desirable, if not necessary, to bring to our readers more that would be useful to them, month by month.

We have been carrying our tables of astronomical phenomena during recent years up to the full measure of the general need of the many amateurs who are interested in this comparatively new branch of astronomy. Variable stars have, also, received large attention as they have deserved, because this branch is certainly one of great worth to the science of astronomy. At the beginning of each year a full run of planetary data is given, like that which is found elsewhere in this issue, so that those interested in the study of the motions of the planets and other simple data about them will have full and exact predictions to guide them for the whole year. In some colleges where the observational plan is part of the regular work in descriptive astronomy, such data given by practical astronomers must be very helpful to instructors who may not have the books, or the time to do all the work necessary to prepare for instruction in this way. That it is the true method which will sometime largely replace others we do not question, for its worth in college work has already been sufficiently tested, and good books have been written embodying the principles and details that make up its working plans.

We have also, always given large attention to cometary data, showing the motions, places at special times, physical characteristics and the properties of their respective orbits. In this most interesting astronomical work we have been largely favored by the astronomers at Lick and Harvard Observatories, and others who have made the observations of comets a part of regular work whenever those irregular visitors appear.

Mr. Percival Lowell and his staff at Lowell Observatory have often given most important studies of the inner group of planets touching and bringing out new and valuable data that seldom has found a parallel anywhere in recent investigation. We hope to be the recipients of like favors in the year to come.

We are extremely glad that Professor Frost Director of Yerkes Observatory has consented, on our personal request, to write an article for Popular Astronomy on some of the recent results of spectroheliography. This we are greatly interested in because we have given, in the past, too little of the fundamentally impor-

tant astronomical work that is now being done in this direction.

The field of astronomical photography is growing so rapidly that it is extremely difficult, for professionals, not directly in its line of work, to keep pace with its rapid advances. Its favorable work on Eros, and the great photographic star catalogue now nearly completed are unique; its very recent success at Lowell Observatory in getting pictures of the surface of Mars that show the canals with certainty plainly indicates what may be hoped for in this line of difficult work in the future. There is also much useful work that the amateur may do with a small camera if he were led into it and likes it well enough to follow it up diligently and very earnestly. Surprises sometimes come from the intelligent use of common and small instruments. A case in point is that a series of photographs of the Sun covering an extended period of time has been very helpful in leading to the possible discovery that the figure of the Sun is not spherical but rather spheroidal, as it should be from the fact that it rotates on its axis once in twenty-five days.

Another part of the field that this publication ought to cover concerns the welfare of the student who is drawn toward astronomy, as a study for a specialty, to prepare himself as an instructor in that branch, or to lay a foundation for a professional life work. In either case there ought to be systematic preparation. The opportunities for such elemental and fundamental work in this country are very few. In our best schools and colleges there are courses enough in mathematics and in astronomy separately considered, but when one comes to the point of preparing himself for instruction in astronomy, or for a position of practical astronomy, it would not be easy for him to find such a school or such a course mapped out for him. It will be part of the purpose of this publication to be helpful, also in this important matter.

It is earnestly hoped that all who have been our supporters in the past will continue to be so in the future. We hope to have from many, monthly, news items of general interest to astronomy and kindred sciences. From practical observers or astronomers, brief accounts of current work in their respective fields of investigation are always very welcome.

Popular Astronomy sends most cordial holiday greetings to all its many friends to all countries in the world.

THE RED SPOT AND SOUTH TROPICAL SPOT ON JUPITER.*

W. F. DENNING.

The red spot has exhibited a very fluctuating rate of motion during the past five years. In 1877 the rotation period of this marking was $9^h\ 55^m\ 33.4^s$, and it showed an uninterrupted, though slightly variable, slackening of speed until 1900, when its period conformed with that adopted for System II of Marth-Crommelin's Ephemeris, viz., $9^h\ 55^m\ 40.63^s$. Since 1900, however, the rate has oscillated between $9^h\ 55^m\ 38^s$ and $9^h\ 55^m\ 42^s$. In the present year, as in 1900, the object has been running nearly level with the rate of System II, and its longitude has not differed materially from 26° since August, 1904. The following are some observations selected from a large number of transits obtained at Bristol in recent years:

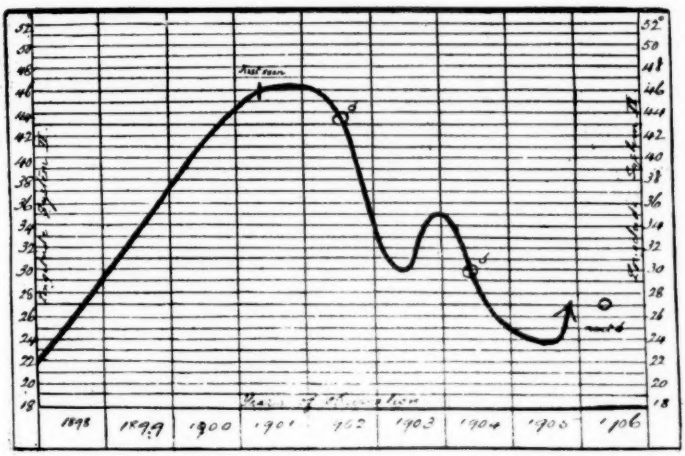
Year.	Date.	Transit Time h	Transit Time m	Longitude of Spot °	Telescope and Power.
1898	June 7	9	20	25.9	10 in. Reflector, 312
1899	Feb. 2	18	39	29.5	" " "
"	Sept. 14	3	59	34.7	" " "
"	Dec. 30	17	54	35.7	" " "
1900	Feb. 20	20	59	37.4	" " "
"	Sept. 3	7	10	44.4	4 in. Refractor, 240
1901	Feb. 13	17	37	43.5	" " "
"	May 28	13	35	45.9	10 in. Reflector, 312
"	Sept. 29	5	54	43.6	" " "
1902	May 20	14	23	44.7	" " "
"	Dec. 31	5	13½	36.3	" " "
1903	May 26	16	18	29.5	" " "
1904	Feb. 2	4	52½	36.0	" " "
"	Oct. 29	8	9	26.4	4 in. Refractor, 150
1905	Feb. 2	7	36	25.4	" " "
"	Mar. 27	6	43	24.6	" " "
"	June 24	15	43	25.1	10 in. Reflector, 215
"	July 16	13	57	24.0	" " "
"	" 30	15	32	23.8	12¼ in. " 315
"	Aug. 1	17	9	22.8	" " "
"	" 18	16	14	23.1	" " "
"	Sept. 13	17	41	22.7	" " "
"	Oct. 6	11	43	23.8	" " "
"	" 15	14	11	26.5	" " "
"	" 17	15	47	25.3	" " "
"	" 22	14	55	25.8	" " "
"	" 24	16	37	28.2	" " "
"	Nov. 3	14	52	28.8	" " "
"	" 6	12	20	28.1	" " "
"	" 7	8	9	26.8	" " "

During the period under review the variable motion of this marking has originated differences in longitude amounting to about 23°. Marked accelerations occurred in 1902 and 1904,

* *Knowledge and Scientific News*, December, 1905.

while the motion was retarded in the last half of 1903, and during the present autumn another decided slackening appears to be in evidence.

To what cause these irregularities have been due appears somewhat doubtful, but it has been conjectured that a large dusky marking, first seen in the spring of 1901, in about the same latitude (south tropical zone), and moving at a more rapid rate than the red spot, has been the means of quickening the speed of the latter. This south tropical disturbance has a rotation period of nearly $9^h\ 55^m\ 19^s$, and, as it overtakes and passes the red spot, may well exercise some accelerating influence upon it. There is indeed strong evidence to support this conclusion, but more observations are required. The two markings were in conjunction in 1902 (July) and 1904 (June), and the phenomenon will be repeated in 1906 (May) if the motion of the red spot remains



VARIATIONS IN MOTION OF THE RED SPOT DURING LAST EIGHT YEARS.

The diagram exhibits the variable motion in longitude of the red spot in and since the year 1898. The conjunctions of this marking with the south tropical spot are also indicted. An inspection of the diagram will show that the motion of the red spot appears to have been accelerated at the time the south tropical spot was first seen, and that both before and after the conjunctions of 1902 and 1904 great accelerations occurred.

approximately the same as during the past twelve months. Taking the mean rotation period of the latter marking in recent years as $9^h\ 55^m\ 40^s$, and that of the south tropical spot as $9^h\ 55^m\ 19^s$, there is a difference of 21 seconds in their times, and this in-

dicates that conjunction must occur at intervals of about 700 days.

Between the present time and next April (Jupiter will be very near the Sun in May and June, 1906) it will be important to secure a large number of accurately observed transits of the red spot for the purpose of determining whether there is any decided increase in its velocity. The south tropical spot is now some 110° east of it (about 3 hours following) and the distance is rapidly closing up. If, therefore, this south tropical disturbance is responsible for the longitudinal displacements of the red spot, the fact will shortly become apparent in a marked increase of the normal rate of the latter, and we shall find its longitude becoming less.

In recent months the south tropical spot has presented a remarkable development, and its length has been augmented from 43.5° to about 60°. My observations of the p. and f. ends of this object during the past four months have been as under:

Date, 1905	Longitude, P. end.	Latitude, F. end.	Length.
	°	°	°
August 7 ..	157.9	201.4	43.5
Sept. 13 ..	140.3	189.9	49.6
Oct. 19 ..	113.3	171.9	58.6
" 31 ..	113.1	170.5	57.4
Nov. 2 ..	108.4	165.8	57.4
" 7 ..	109.6	167.0	57.4
" 11 ..	108.5	170.7	62.2

The increase of length between August 7 and October 19 was 15°, which corresponds to a real distension of about 11,000 miles. This enlargement must have occurred chiefly at the following side of the spot, which has drifted far East relatively to the rotation of $9^h\ 55^m\ 19^s$, representing the normal rate.

While writing I may note that the present autumn has furnished many excellent observing nights. Between October 7 and 14 the weather was very cloudy, but between October 15 and November 11 there were 22 nights clear and 6 overcast. On quite a large proportion of the clear nights planetary definition was found very sharp. This was especially the case on November 6, when I tried powers of 713, 912, 1210 and 1540 on my 12½ inch reflector. The details could be well seen on Jupiter with the latter power; but the difficulty of getting the image into the field, and keeping it there, rendered the use of lower powers much preferable.

THE SUN AS A MAGNETIZED SPHERE. *

The radical change, gradually brought about by numerous physical researches, in our ideas regarding the ultimate constitution of matter, by which we conceive of atoms as composed of dynamic structures of balanced rapidly rotating electric charges, has, also, materially modified the attitude of mind in which we approach the problem of the magnetization of large rotating heavenly bodies. When the atoms were regarded as hard, highly elastic, nonelectrical, and nonmagnetic spheres moving by the laws of kinetic energy in straight paths, except for the effect of collisions, it was of course difficult to prove that the Sun could be magnetic of itself at the high prevailing temperature. But if the integrated forces are to be derived from electric charges in very rapid motion, and this seems to be the case, then magnetic fields are essential to the existence of every kind of matter whether in large or in small masses. Under ordinary conditions the primitive motions of the ionic charges are highly disorganized, since the motions are in every conceivable plane, and the molar or large masses do not show any outside field of force. It is, however, only necessary to organize these ionic motions relative to one plane, that is to polarize their orbits, in order to produce a common magnetization within the mass and magnetic field outside this body. When a steel magnet is subject to heat the field is destroyed, simply because the minor magnets, as of the atoms and molecules temporarily oriented to one axis, have been made disordered by the higher class of collisions which has been induced by the increase of the temperature. This experiment, however, by no means exhausts the natural conditions of the problem. In a rotating body like the Sun the angular velocity induces a deflecting force at right-angles to the momentary motion, of every particle, $I = \omega\, q \cos\theta$, depending on the angular velocity, and polar distance velocity in any linear direction. When q is great, and in the case of the negative ions combined in the atom, it may approach the velocity of light, I is also a comparatively large force, so that a tendency to run into vortex motion is ever in operation. The entire mass of the Sun, by the general laws of motion, also is evidently organized as a great vortex about the axis of rotation, and these two impulses doubt-

* The above extract is taken from a very valuable paper by Professor Frank H. Bigelow of Washington, D. C., which appeared in the *Monthly Weather Review* No. 8, page 357, 1905.

less tend to polarize the motions of the individual atomic ions in planes perpendicular to this axis, or to produce magnetization nearly parallel to the axis of rotation. Since the movement of the negative ions is in excess of that of the positive ions, the resultant magnetic field will be due to this excess of the action of negative electric charges above the positive charges, since for a common direction of gyration the positive and negative charges produce oppositely directed magnetic field. Finally, if the negative charges, in the atomic conflict, tend to escape from their electric bonds and to roam in disregard of any structure, then these negative charges may well tend to accumulate as an electrostatic layer on the surface of the sphere. At least the negative body-charge may, as a whole, be located farther from the center of the sphere than the positive body-charge, and this will produce internal magnetization and surface electrostatic charge, such as the earth possesses, and such as we have evidence to indicate that the Sun also possesses. This dynamic view of mine comes to the same result as the static theory explained by Sutherland.* With this introduction I shall merely mention various results obtained in my researches, which are at least circumstantial evidence that the Sun is a highly organized magnetic body, and that the numerous variations in its internal action constitute the causes for the observed changes in the external magnetic field.

(1) The polar rays of the corona, at least at minimum, conform to the normal lines of magnetic force on a sphere seen in projection, and concentrated in a ruffle at some distance from the pole.

(2) The ions in the solar atmosphere are luminous along rays of magnetic force.

(3) The coronal poles are located asymmetrically with respect to the axis of rotation, and persist from one eclipse to another in the same relative positions.

(4) The Sun's external magnetic field, as measured at the earth, is so arranged that it has greater intensity in some solar longitudes than in others.

(5) By using large masses of observational material, the typical curve, attributed to difference in solar output in longitude and depending for its existence upon the structure of the Sun's nucleus, has been found to be reproduced approximately, in the distribution of the Sun's spots and prominences in longitude, in the terrestrial magnetic elements, the electric field, the baromet-

*A possible cause of the earth's magnetism, W. Sutherland, Terr. Mag., June 1900; September, 1900; December, 1904.

ric pressures, the temperatures, and the local cyclonic movements in the United States.

(6) There is evidence that the periods of rotation in the higher latitudes of the Sun fluctuate about a mean value synchronously with the external energy variations, showing that the entire external system is a direct effect of the forces producing at the same time the interior circulation in the mass of the Sun.

(7) The inference is that the Sun's magnetic field embraces the earth, and reaches it in lines perpendicular to the ecliptic falling upon the polar regions of the earth along the planes of the magnetic meridians.

THE RADIATIONS OF THE SUN.

The electromagnetic radiation of the Sun transports to the earth the other kind of energy which is concerned in the temperature excess prevailing in the Tropics over that in the polar zones, and produces the observed general and local cyclonic circulations. The coronal rays, especially in the equatorial belts of the Sun, indicate that there are other forces in operation in the neighborhood of the photosphere besides those already mentioned.

(1) The spreading of the great streamers away from the plane of the ecliptic suggests an electrostatic repulsion.

(2) The streams of ions, under the action of the mechanical pressure of light, move not in radial lines, but in curves as determined by the additional magnetic and electrostatic forces prevailing in the surrounding space.

(3) It is impossible to assert that enough ions reach the upper strata of the earth's atmosphere to produce the observed variations of the terrestrial-magnetic and electric fields as registered in the lower strata, and it is not probable that this is the fact.

(4) The radial radiation of the photosphere may be to some extent variable in its output, and so produce seasonal climatic temperature and weather variations synchronous with it, as registered in the pressures and temperatures in different regions of the earth.

(5) The normal equilibrium of the earth's atmosphere is probably disturbed frequently, from day to day and hour to hour, by the interplay of this complex system of correlated forces.

THE METEOROLOGICAL EFFECTS OF THE SOLAR ENERGY.

The problem of discussing the effects of the solar radiation upon the magnetic and the electrical fields of the earth's atmosphere, and their relations to the meteorological elements, has been

greatly simplified by the results of the research contained in the first four papers of this series. It has been shown that a different correlation of the quantities in consideration can be made and that in this way the intractable conditions which have so long puzzled scientists are decidedly ameliorated.

(1) The fact that there is no one synchronism common to the entire earth between solar and terrestrial causes and effects, has been explained by showing that the temperatures synchronize directly in the tropical zones, but only inversely in the temperate zones, in consequence of the inverting effects of the general circulation; and that while the pressures in the Eastern Hemisphere respond directly to the solar impulse, they surge inversely to it in the Western Hemisphere. Similarly, the precipitation and the local circulation will have to be distributed by regional conditions in the final interpretation. This will reconcile much data that are apparently in conflict as evidence regarding the existence of synchronism generally.

(2) The discovery of ionization in the gases of the atmosphere, generated probably by the short-wave radiation, and the determination of the several types of the temperature waves in the lower strata of the atmosphere, lifts the veil from the problems of the diurnal barometric waves, the electric potential gradient, and the rate of change in the electric charges. These seem to be direct consequences of the temperature acting upon the density of the air in the different strata, and upon the locality, whether warm or cold, sought out by the ions.

(3) The cause of the *hourly* variation of the magnetic field is plainly shown to reside in the movements of the ions from one level to another. The cause of the *daily* variation of the magnetic field is probably in large part due to the movement of the ions from one hemisphere to the other, which at the same time produce the auroral displays simultaneously in each hemisphere, and the electric earth currents as local effects in the several portions of the circuit. This change of view relieves us of the difficulty of making the Sun the source of all the energy displayed in a large magnetic storm, since the initial impulse is due to that portion of the energy disturbing the normal terrestrial equilibrium, while much of the observed effect is due to the motion of the ions in a closed terrestrial circuit. It remains to discover in what proportion the energy should be distributed among these three sources, the polar magnetic field of the Sun, the variable energy, and the terrestrial ionic circuit.

(4) It is now apparent that in using, for the basis of my origi-

nal research, the magnetic field of the earth as a register or solar pulse recorder, I have been amply justified in tracing out through it as the intermediary the synchronism between the solar surface variations, shown by the spots, faculæ, and prominences, and the temperature and pressure effects at the earth, because it is in fact an intermediate effect, and evidently the most sensitive one with which we have to deal. The subtile influences of the invisible solar radiation may be registered in several ways, as bolometric spectrum curves, as actinometer integrations, as visible energy spectra, or they may be recorded as elastic potential effects and as magnetic force vectors. The latter are the most persistent in all kinds of weather, and most available for continuous observations. It is only necessary to determine what the connecting functions are in terms of magnetic force to infer from the magnetic intensity what are the temperatures within two miles of the ground, in the midst of the cyclonic actions, to estimate the movement of the ionic currents, and to determine the relative amount of the incoming solar radiation, and thence to learn much regarding the variable nature of the circulation within the rotating mass of the Sun.

(5) It is now easy to see that several lines of scientific inquiry as to the period of the solar rotation have been misdirected. The attempt to associate magnetic storms with the solar spots has failed, because the effective surface radiation on a given meridian of the Sun may or may not be associated with a large spot, which clearly depends upon the internal circulation for its existence. Besides this, the magnetic storm is in part dependent upon distinctly terrestrial conditions. The application of Schuster's periodogram to the magnetic declination, in order to determine the periodicity of the solar residuals, was incorrect for this reason. While the magnetic declination varies with the season of the year, and from one year to another, as a consequence of the solar radiation, this component is really a term in the hourly vectors only, due to the vertical rise and fall of the ions from one stratum to the other. On the other hand the horizontal and the vertical components are the only ones which the terrestrial ionic circuits between the two poles will affect, while the declination is wholly subordinate. The rotation of the Sun on its axis will in any event, whether the energy is transported in the oval polar circuit or as a linear radial radiation, not much influence the declination from day to day. It was a misapplication to assert that negative results of the periodogram carry with them a decisive critical meaning regarding any solar period. This tendency

to mix up terrestrial and solar data in the same mass of numerical quantities, has been also found in the count of the number of the solar prominences, and is no doubt to some extent unavoidable since in our common observations we are not readily able to distinguish between them,but it is my opinion that in the present stage of the science it is better to employ a simple comparison of the data as they stand for the discovery of synchronism and periodicity, rather than to bury the several impulses in one massive computation. What is at present urgently required in this research, is to bring together all the data in simple homogeneous series, as in a carefully constructed ephemeris, for each of the several elements of the entire problem, determine what is solar and what is terrestrial, and then introduce terms in the functions which will give some chance of separating the unknowns in a satisfactory analysis. This result will best be reached by intelligent coöperation, and I have no doubt that practical methods may be devised by means of which this purpose can be accomplished. It seems to me a very important advance to have gained a general view from which to correlate and harmonize so many of the problems that have heretofore been insoluble.

THE TERRIBLE "HOODOO" OF ECHO MOUNTAIN.*

Echo Mountain's famous "hoodoo" has done its worst. The destructive fire that Saturday swept up the sides and over the summit of that sightly eminence nestled against Mount Lowe seems to have left nothing to satisfy the future greed of the bogie that has exerted its influence ever since the completion of the incline railway. It has made a clean sweep of buildings and about everything else but Observatory, sky-line and entrancing view.

The havoc of fire always is regrettable, and especially is it so when, as in this instance, not only the works of man have fed the flames, but those of God, as well, for many fine trees went up in smoke and the steep sides of the mountain are blackened and in places crumbling from the heat.

If the industrious and overtimeworking "hoodoo" can do anything worse than it has done to Echo Mountain and Mount

* This brief graphic editorial in the *Los Angeles Times* of December 11, 1905 will interest many readers who have some knowledge at least, of what has been done for Astronomy, on the mountain peak, near Los Angeles, and the dangers from fire and storm to which these mountain stations are sometimes subjected. More is given in detail elsewhere, about the dreadful work of the fire and the mountain storm-king in this last fit of destructive wrath. Ed.

Lowe, it would be hard to conceive of the particular form its wrath might take. Forest fires, some of them of almost obliterating intensity, have swept up the mountain sides, seared out the beauties of the cañons and left general desolation in their wake. About five years ago a vast expanse of the mountain forests was burned out, and there have been numerous smaller forest fires since and before that time.

What appeared to be the crowning calamity, however, came about six years ago, when the large hotel on Echo Mountain, one of the drawing cards for tourists, caught fire early one morning and burned—a spectacular blaze a mile in the air, that made a profound impression on the comparatively few persons who witnessed it.

But Echo Mountain was rehabilitated after that apparent finish. In the course of time the debris was cleared away. Then followed promises of the handsome new hotel that was to take the place of the old. These hints comprised everything in the way of building materials, from log with the bark on to Carrara marble.

Since then the property has passed into the hands of Mr. Huntington and many improvements have been made. The fire of Saturday December 9, has helped him in his work of clearing the ground for greater improvements. It has provided the site and the need for the long promised hotel. His opportunity has come to crown the mountain-top with a building that, in meeting the demands of his artistic fancy, will prove the most attractive and commanding of all the show places of the great Southwest. Speed the new hotel which all American travelers would long to see!

Astronomical Phenomena of 1906.

ECLIPSES.

There will be five eclipses, three of the Sun and two of the Moon during the year 1906. The eclipses of the Sun are all partial and are visible principally in polar regions. Only one, that of August 19, is visible at all in the United States, and that only in the northwestern part. The following data are taken from the *American Ephemeris* for 1906.

(1) *A Total Eclipse of the Moon February 8*, will be visible generally throughout North and South America. The beginning will be visible in the western parts of Europe and Africa and the ending in the northwestern portions of Asia and Eastern Australia.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of opposition in right ascension, February 8, $19^h\ 49^m\ 58^s.5$.

	h	m	s		s
Sun's right ascension	21	28	21.59	Hourly motion	9.94
Moon's right ascension	9	28	21.59	Hourly motion	137.85
Sun's declination	−14	55	23″.6	Hourly motion	+ 0′ 47″.6
Moon's declination	+14	48	15 .7	Hourly motion	− 7 42 .0
Sun's equa. hor. parallax			8 .9	Sun's true semidiam.	16 12 .5
Moon's equa. hor. parallax		58	0 .9	Moon's true semidiam.	15 47 .7

TIMES OF THE PHASES.

	h	m	
Moon enters penumbra February 8,	16	54.1	Greenwich Mean Time.
Moon enters shadow	17	57.0	
Total eclipse begins	18	57.8	
Middle of the eclipse	19	47.0	
Total eclipse ends	20	36.2	
Moon leaves shadow	21	37.0	
Moon leaves penumbra	22	39.9	

Magnitude of the eclipse = 1.631 (Moon's diameter = 1.0).

(2) *A Partial Eclipse of the Sun, February 22.* — This will be visible only on the Antarctic Ocean and a small part of Australia.

Greenwich mean time of conjunction in right ascension, February 22, $19^h\ 03^m\ 44^s.3$.

ELEMENTS OF THE ECLIPSE.

	h	m	s		s	s
Sun and Moon's R. A.	22	22	42.31	Hourly motions	9.53 and	126.61
Sun's declination	−10°	07′	47″.2	Hourly motion	+ 0′	54″.7
Moon's declination	−11	20	40 .5	Hourly motion	+ 8	58 .0
Sun's equa. hor. parallax			8 .9	Sun's true semidiam.	16	09 .6
Moon's equa. hor. parallax		56	21 .9	Moon's true semidiam.	15	20 .8

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time.		Longitude from Greenwich		Latitude	
	h	m	°	′	°	′
Eclipse begins February 22	17	57.9	20	43.6 W	66	48.6 S.
Greatest Eclipse	19	43.3	170	08.3 W	71	31.4 S.
Eclipse ends	21	29.1	138	50.5 E	37	01.7 S.

Magnitude of greatest eclipse = 0.537 (Sun's diameter = 1.0).

(3) *A Partial Eclipse of the Sun, July 20-21.* — This will be visible only on the Antarctic Ocean.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, July 21, $1^h\ 30^m\ 29^s.5$:

	h	m	s		s	s
Sun and Moon's R. A.	7°	59′	45″.06	Hourly motions	10.00 and	132.16
Sun's declination	+20	36	02 .1	Hourly motion	− 0′	28″.4
Moon's declination	+19	20	03 .8	Hourly motion	− 3	27 .8
Sun's equa. hor. parallax			8 .7	Sun's true semidiam.	15	44 .5
Moon's equa. hor. parallax		55	33 .2	Moon's true semidiam.	15	07 .5

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time.			Longitude from Greenwich.			Latitude.	
		h	m	°	′		°	′
Eclipse begins	July 20	23	48.7	58	26.1	W.	50	32.9 S.
Greatest Eclipse	21	1	14.4	33	15.1	W.	68	37.2 S.
Eclipse ends	21	2	39.9	11	26.2	E.	59	44.8 S.

Magnitude of Greatest Eclipse = 0.335 (Sun's diameter = 1.0).

(4) *A Total Eclipse of the Moon, August 4.* — This will be invisible in the eastern part of the United States. The beginning will be visible in the central and western portions of North America, the eastern portions of Asia and Australia. The ending will be visible in Alaska and throughout Asia and Australia.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of opposition in right ascension, August 4, $1^h\ 01^m\ 05.^s6$.

	h	m	s			s
Sun's right ascension	8	54	41.6²	Hourly motion		9.65
Moon's right ascension	20	54	41.6²	Hourly motion		145.09
Sun's declination	+17	25	07.0	Hourly motion	− 0′	39″.5
Moon's declination	−17	22	17.4	Hourly motion	+ 6	31 .2
Sun's equa. hor. parallax			8.7	Sun's true semidiam.	15	46 .0
Moon's equa. hor. parallax		58	54.5	Moon's true semidiam.	16	02 .4

TIMES OF THE PHASES.

	h	m	
Moon enters penumbra August	3	22	11.7
Moon enters shadow	3	23	10.5
Total eclipse begins	4	0	09.3
Middle of eclipse	4	1	00.2
Total eclipse ends	4	1	51.1
Moon leaves shadow	4	2	49.8
Moon leaves penumbra	4	3	48.6

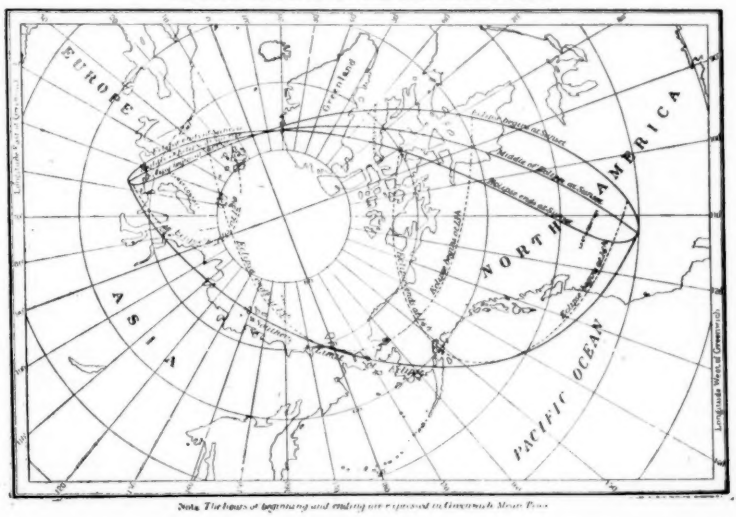
Greenwich Mean Time.

Magnitude of eclipse = 1.786 (Moon's diameter = 1.0)

(5). *Partial Eclipse of the Sun August* 19. — This will be visible on the Arctic Ocean, in Alaska, the western part of British America and in the northwestern part of the United States.

The regions in which this eclipse is visible are shown upon the accompanying chart.

PARTIAL ECLIPSE OF THE SUN AUG. 19TH 1906.



Note. The hours of beginning and ending are expressed in Greenwich Mean Time.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, August 19, $12^h\ 33^m\ 47.^s8$.

		h	m	s		s	s
Sun and Moon's R. A.		9	53	18.16	Hourly motions	9.30 and	131.86
Sun's declination	+12°	49′	52″	6	Hourly motion	— 0′	48″.9
Moon's declination	+14	10	30	.8	Hourly motion	— 8	22 .8
Sun's equa. hor. parallax			8	.7	Sun's true semidiam.	15	48 .5
Moon's equa. hor. parallax		57	01	.4	Moon's true semidiam.	15	31 .6

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time.		Longitude from Greenwich.			Latitude	
	h	m	°	′		°	′
Eclipse begins August 19	11	53.4	48	46.1	E.	71	46.1 N.
Greatest eclipse	13	12.9	66	13.0	W.	70	54.9 N.
Eclipse ends	14	32.7	113	22.5	W.	46	39.7 N.

Magnitude of greatest eclipse = 0.314 (Sun's diameter = 1.0).

THE PLANETS.

The apparent paths of the planets among the stars for the year 1906 are shown upon the charts, Figures 1 and 2. In these only the stars rated as bright as the fourth magnitude are platted.

Mercury begins the year in Scorpio having just turned eastward on the loop which was not completed on our chart for last year. His motion is eastward along the ecliptic until April, when a closed loop is described in the constellation Pisces, as Mercury passes between the Sun and the earth. Inferior conjunction will occur on April 4, greatest elongation March 18, and greatest western elongation May 2. The planet then moves eastward along the ecliptic, at first south, then north, then again south of the ecliptic, until the latter part of July, when it will make another closed loop in the constellation Leo, being at inferior conjunction August 12. Greatest eastern elongation here occurs July 15, and greatest western elongation August 29. Another great loop is described in the constellation Scorpio in November and December, only a small part of the loop being closed, the whole being like a reversed capital S with the upper half crushed together. Inferior conjunction occurs November 29, and greatest eastern elongation November 9, and greatest western elongation December 18.

Venus will describe the path represented by the dotted line on the chart, the motion being forward along the ecliptic until November, when this planet, like Mercury, will traverse a great reversed S in Scorpio. The two planets will be at inferior conjunction on the same day November 29, only about one hour apart in time, the conjunction of Venus coming at 11^h and that of Mercury at 12^h Central Standard time. It will be evident from the chart that Mercury at this time will be north of the Sun and that Venus will be south of the Sun, for the apparent path of the Sun's center is represented by the ecliptic.

Mars starts in Aquarius not far from Saturn and moves eastward along the ecliptic during the entire year, his course ending in Libra. Mars will be in conjunction with the Sun July 15, and his position will not be favorable for observations at any time this year, the distance of the planet from the earth being most of the time more than twice as great as that of the earth from the Sun.

Jupiter will traverse a course about thirty degrees long in Taurus and Gemini, retrograding just south of the Pleiades during the first month, then advancing quite close along the ecliptic until November, then retrograding until the end of the year. Jupiter will come to opposition on December 28, and will be in splendid position for observation from October on. The relation of the orbits of the four bright satellites is shown in the diagram Fig. 3. The inner, fifth, satellite, whose

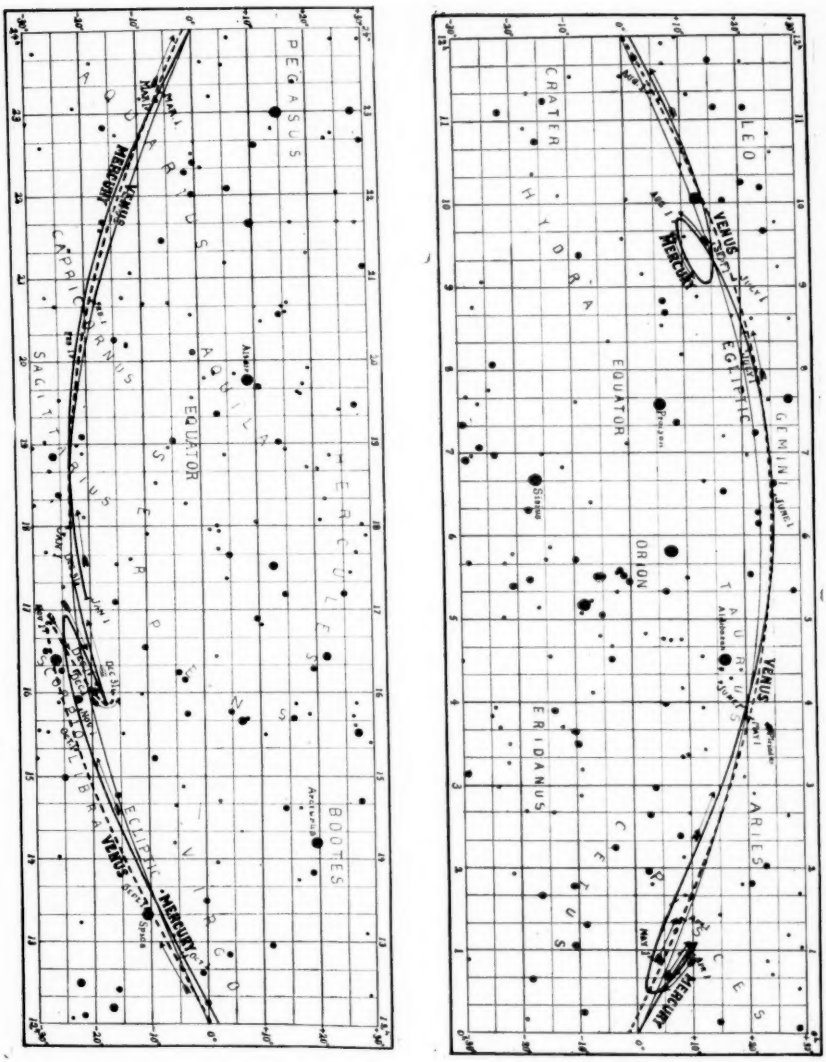


FIG. 1. THE APPARENT PATHS OF THE PLANETS MERCURY AND VENUS DURING THE YEAR 1906.

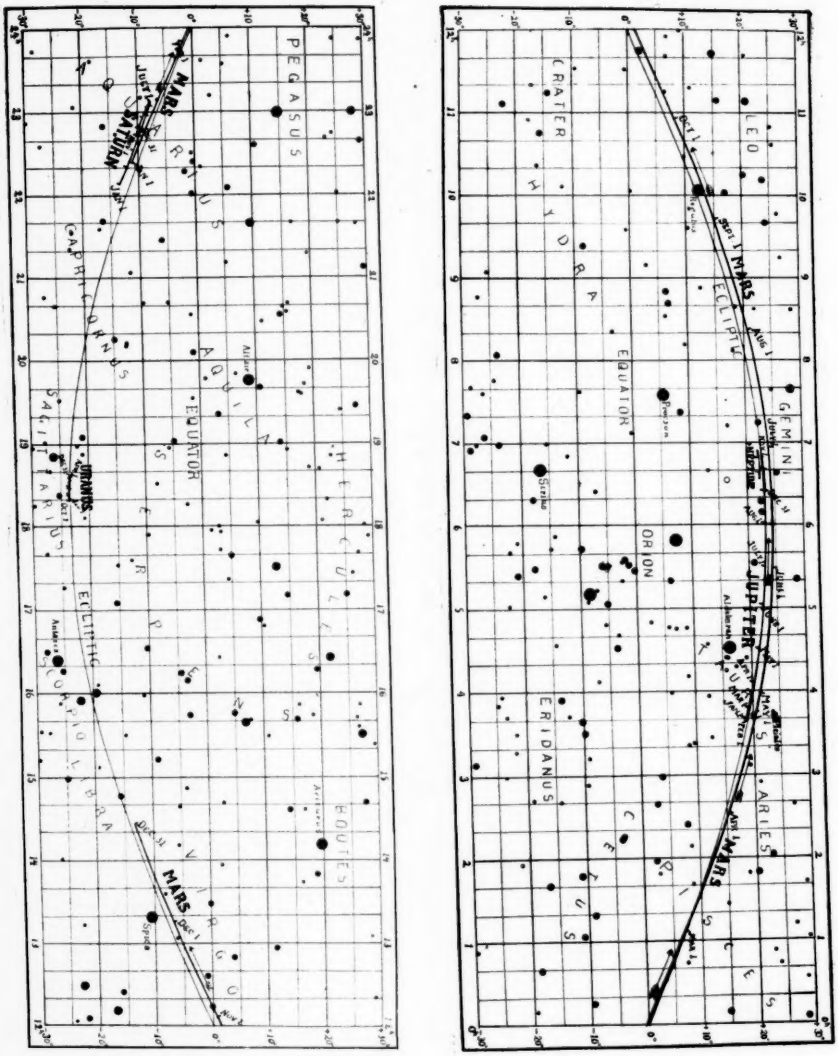


FIG. 2. THE APPARENT PATHS OF THE PLANETS MARS, JUPITER, SATURN, URANUS AND NEPTUNE DURING THE YEAR 1906.

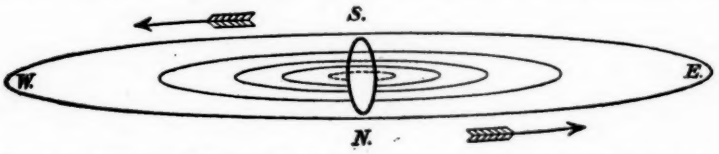
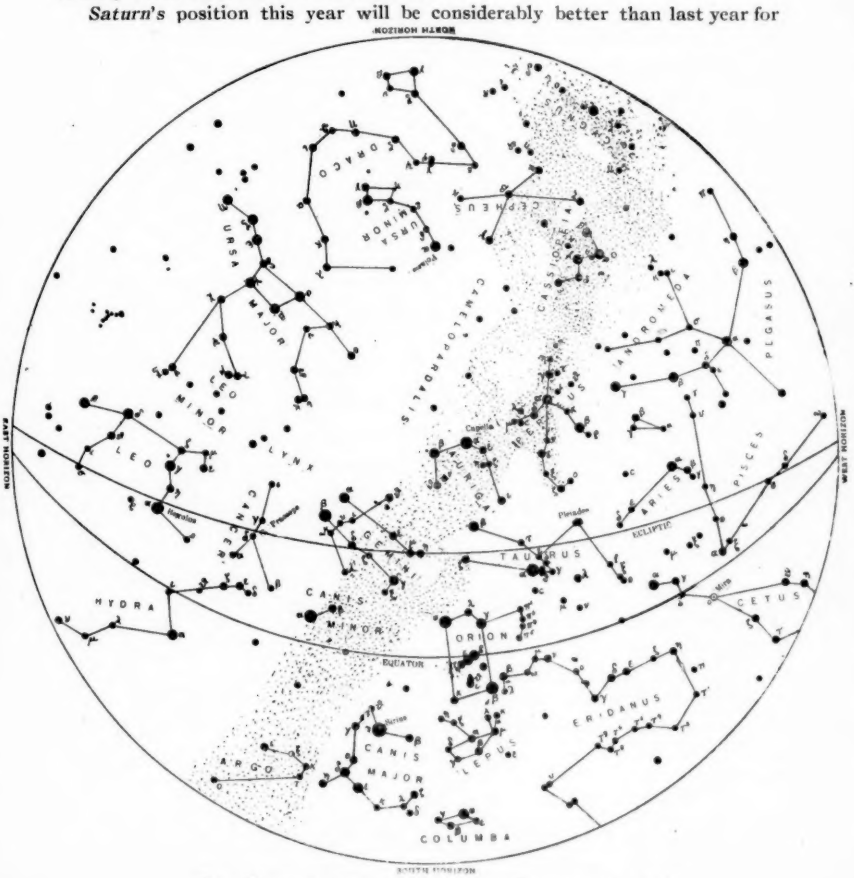


FIG. 3. APPARENT ORBITS OF THE SATELLITES OF JUPITER AS SEEN IN AN INVERTING TELESCOPE IN 1906.
(The vertical scale is three times the horizontal one.)

orbit is represented by the dotted ellipse, is not visible in an ordinary telescope. The new, outer satellites, six and seven, have very different orbits from those of the inner satellites. They were discovered by photography and have not as yet been visually observed so far as we are aware.

Saturn's position this year will be considerably better than last year for



THE CONSTELLATIONS AT 9 P. M., FEBRUARY 1, 1906.

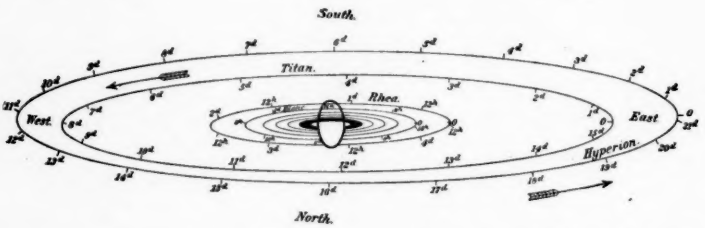


FIG. 4. APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN AS SEEN IN AN INVERTING TELESCOPE IN 1906.

observers in our latitude. At opposition in September the planet will be less than ten degrees south of the equator. The relation of the orbits of the seven inner satellites is shown in the diagram Fig. 4. The elevation of the earth above the plane of the rings diminishes from 10° in January to 3° in June, then increases to 6.°4 in November, and decreases after that time. The apparent course of Saturn is eastward through Aquarius until July then retrograde until November, and eastward for the rest of the year.

Uranus pursues a short course of about five degrees length in Sagittarius, going over this course three times during the year, first eastward, then westward, then again eastward. The altitude of Uranus at best will be too low for satisfactory observations in our latitude.

Neptune's path for 1906 is also about five degrees long, being retrograde from January 1, to March 20, then direct until October 15, and retrograde during the rest of the year. Neptune is in the constellation Gemini in the best possible position for observation by northern observers, except for the fact that its opposition comes in the middle of winter.

PHASES OF THE MOON.

Washington Mean Time

New Moon.			First Quarter.			Full Moon.			Last Quarter.		
	h	m		h	m		h	m		h	m
Jan. 24	0	01.0	Jan. 1	21	44.0	Jan. 9	23	28.5	Jan. 17	3	40 5
Feb. 22	14	48.4	Feb. 0	19	22.6	Feb. 8	14	37.4	Feb. 15	11	14.2
Mar. 24	6	43.6	Mar. 2	16	20.0	Mar. 10	3	09.1	Mar. 16	18	49.1
Apr. 22	22	58.2	Apr. 1	10	53.7	Apr. 8	13	04.1	Apr. 15	3	28.2
May 22	14	52.3	May 1	1	58.6	May 7	21	01.4	May 14	13	54.4
June 21	5	57.3	May 30	13	15.4	June 6	4	03.4	June 13	2	26.1
July 20	19	50.8	June 28	21	10.6	July 5	11	19.2	July 12	17	04.5
Aug. 19	8	19.2	July 28	2	48.0	Aug. 3	19	51.4	Aug. 11	9	39.2
Sept. 17	19	25.2	Aug. 26	7	34.2	Sept. 2	6	28.1	Sept. 10	3	45.3
Oct. 17	5	31.4	Sept. 24	13	03.2	Oct. 1	19	40.1	Oct. 9	22	31.0
Nov. 15	15	28.2	Oct. 23	20	41.5	Oct. 31	11	37.5	Nov. 8	16	36.6
Dec. 15	1	46.0	Nov. 22	7	31.1	Nov. 30	5	59.0	Dec. 8	8	36.8
			Dec. 21	21	55.4	Dec. 30	1	35.5			

OCCULTATIONS.

A list of 104 occultations of stars by the Moon is given in the *American Ephemeris*, as being visible at Washington during this year. We shall give the lists for each month in POPULAR ASTRONOMY one month ahead of time, so that our readers will have ample notice of each. The list for February is as follows:

OCCULTATIONS VISIBLE AT WASHINGTON.

Date 1906.	Star's Name.	Magnitude.	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N pt.	EMERSION. Washington M. T.	EMERSION. Angle f'm N pt.	Duration.
			h m	°	h m	°	h m
Feb. 2	BD. +14° 657	5.9	13 21	112	14 17	234	0 56
3	Bradley 686	5.7	12 41	158	13 02	196	0 21
7	d^2 Cancri	6.2	7 56	142	8 49	229	0 53
8	π^2 Cancri	5.6	4 57	95	5 51	278	0 54
10	ν Leonis	4.2	13 52	147	15 01	268	1 09
16	29 Ophiuchi	6.4	17 25	151	18 21	240	0 56
25	14 Ceti	5.4	6 44	46	7 44	270	1 00

COMETS.

The two comets *b* and *c* 1905, which have recently been discovered, will be visible during a part of the year 1906. Comet *b* is waning rapidly and will probably become entirely invisible during January. Comet *c* will go behind the Sun in January, but is likely to emerge in the latter part of the month or in February and become quite a brilliant object. The elements at hand are as yet too uncertain to form a basis for confident prediction.

Of the periodic comets no less than eight are due at perihelion this year, provided their periods have not been materially changed since they were last seen. Only three, however, offer much probability of their being detected.

(1). Holmes' comet 1892 is due at perihelion about the middle of March, but will then be almost directly behind the Sun.

(2). Barnard's comet 1884 II has not been observed since 1884. This year it will be almost directly behind the Sun at the time of perihelion in March and so cannot be seen.

(3). Biela's long lost comet is also due in March and should be in favorable position for observation in April and May, if there be anything left of the comet to observe and if it be moving in the orbit which it had in 1866, all of which is quite improbable.

(4). Brorsen's lost comet too should be at perihelion in June but will then be behind the Sun. It has not been seen since 1879.

(5). The comet 1894 IV, discovered by E. Swift and thought for some time to be probably identical with DeVico's comet 1844 I, is due at perihelion July 1, but will be in less favorable position than in 1900, when it was not picked up, so that the probability of its being found this year is very small.

(6). Denning's comet 1881 V has a period of about 8⅓ years. During the two apparitions since its discovery it was in unfavorable position, and was not seen, but this year, if the period is correct, it should reappear under almost the same conditions as in 1881. It should be at perihelion in the latter part of September.

(7). Finlay's comet 1886 VII will also be in excellent position for observation during the latter part of the year. It comes to perihelion in October just a few days after the earth has passed the same longitude As the inclination of the comet's orbit is small there will be quite a close approach to the earth.

(8). Swift's comet 1889 VI, if the period 8.53 years be correct, was behind the Sun in 1898 and so could not be seen. This year it should be in nearly the same position relative to the earth and Sun as in 1889. It was then very faint however, so that a small change in the period may render the comet wholly invisible.

METEOR SHOWERS.

The following list of radiant points of meteoric showers is taken from a list of 90 radiant points given by Mr. W. F. Denning in the *Companion to the Observatory* for 1905.

Date.	Radiant.		Remarks.
	α	δ	
Jan. 2-3	230°	+ 53°	Swift; long paths.
Apr. 20-22	271	+ 33	Swift.
May 1-6	338	— 2	Swift: streaks.
July 28	339	— 11	Slow; long.
Aug. 10-12	45	+ 57	Swift; streaks.
Oct. 18-20	92	+ 15	Swift; streaks.
Nov. 14-16	150	+ 22	Swift; streaks.
Nov. 17-23	25	+ 43	Very slow; trains.
Dec. 10-12	108	+ 33	Swift; short.

The Perseids, with a maximum on August 11, are visible for a considerable period and their radiant exhibits a motion, to the E. N. E. among the stars of about 1° per day. Its position for July 19 should be α 19°, δ + 50°, and on Aug. 16, α 53°, δ + 58°.

Phenomena of Jupiter's Satellites.

[Central Standard Time.]

The hours after Midnight are numbered 12h, 13h, 14h, etc.

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., denotes occultation; Tr., transit of the satellite; Sh., transit of the shadow.

	h	m			h	m	
Feb. 1	6	15	I Ec. Re.	Feb. 11	30		I Tr. Eg.
2	5	28	II Tr. Eg.	15	6	13	III Ec. Re.
	5	29	II Sh. In.		6	35	I Oc. Dis.
	8	7	II Sh. Eg.		10	6	I Ec. Re.
4	6	5	III Tr. Eg.	16	5	58	I Tr. Eg.
	9	20	III Sh. In.		7	18	I Sh. Eg.
	11	22	III Sh. Eg.		8	3	II Tr. In.
6	10	12	I Oc. Dis.		10	41	II Tr. Eg.
7	7	22	I Tr. In.		10	45	II Sh. In.
	8	41	I Sh. In.	18	7	37	II Ec. Re
	9	35	I Tr. Eg.	21	11	12	I Tr. In.
	10	32	II Oc. Dis.	22	7	22	III Ec. Dis.
	10	54	I Sh. Eg.		8	31	I Oc. Dis.
8	8	10	I Ec. Re.		9	15	III Ec. Re.
9	5	23	I Sh. Eg.	23	5	41	I Tr. In
	5	26	I Tr. In.		7	00	I Sh. In
	8	3	II Tr. Eg.		7	54	I Tr. Eg.
	8	7	II Sh In.		9	14	I Sh. Eg.
	10	45	II Sh. Eg.		10	43	II Tr. In.
11	7	59	III Tr. In.	24	6	31	I Ec. Re.
	10	2	III Tr. Eg.	25	7	38	II Oc. Re.
14	9	16	I Tr. In.		7	40	II Ec. Dis.
	10	36	I Sh. In.		10	13	II Ec. Re.

COMET AND ASTEROID NOTES.

Comet *b* 1905 (Schaer), as shown by the ephemeris which follows, has already passed to the south of the equator and is becoming exceedingly faint. The diagram which we have prepared will show the course of the comet relative to the earth, if the reader will imagine the orbit of the comet to be revolved about the line of nodes so as to make an angle of 40° with the plane of the earth's orbit. The curve as platted is the projection of the true path upon the plane of the earth's orbit. It will be plain that the comet was at about its nearest approach to the earth at the time of its discovery on November 17, and that it is now rapidly receding from the earth. The diagram has been prepared with the aid of Miss Lamson's elements, which are given in another note. In the Lick Observatory Bulletin No. 86, Messrs. R. T. Crawford and A. J. Champreux give the following elements, computed by Leuschner's "Short Method" without assumption regarding the eccentricity. The period obtained, 160.6 years, must be regarded as very uncertain, since Miss Lamson's parabolic elements satisfy the observations almost equally well.

$T = 1905$ Oct. 25.02430
$\omega = 132°\ 07'\ 26''.8$
$\Omega = 223\ \ 04\ \ 08\ .3$ 1905.0
$i = 140\ \ 27\ \ 14\ .0$

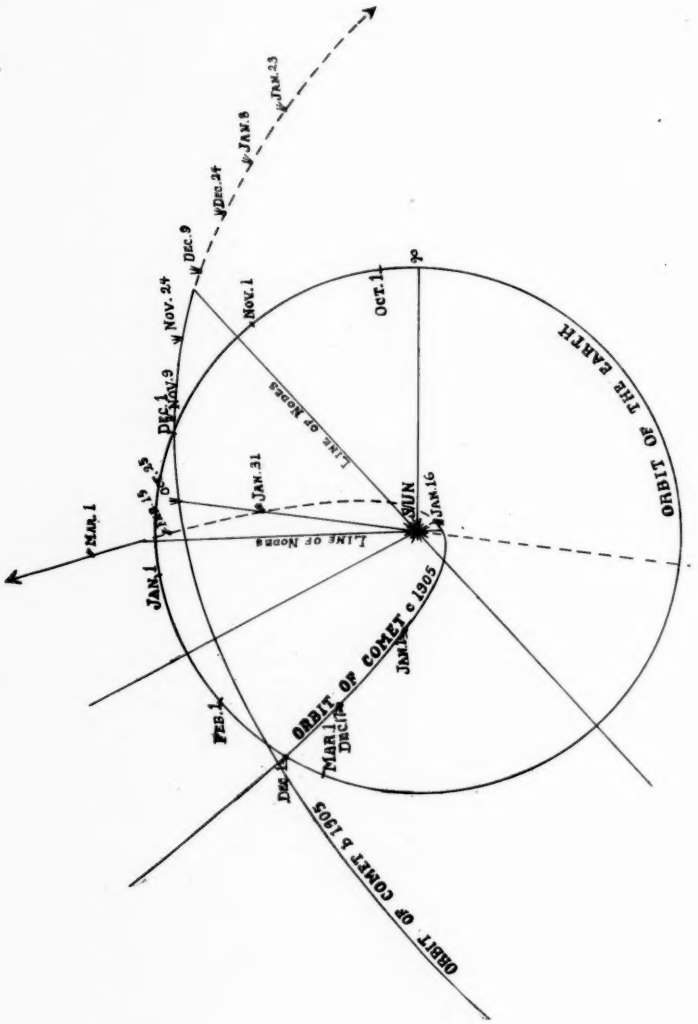
$\log a = 0.020856$
$\log e = 9.984301$
$q = 1.049195$
$\log \mu = 1.344119$
Period = 160.6526 years.

On December 15, as observed at Northfield, the comet was pretty faint and was just barely visible with the five-inch finder. It was close to the ephemeris place.

EPHEMERIS OF COMET *b* 1905.

[From elements by Crawford and Champreux. Lick Observatory Bulletin No. 86.]

		True α			True δ			log *r*	log Δ	Brightness.
		h	m	s	°	′	″			
Dec.	3.5	23	30	07.9	+ 0	25	18		9.7463	
	4.5		30	06.2	− 1	06	59			
	5.5		30	07.6	2	28	56	0.0957	9.7964	0.13
	6.5		30	11.8	3	42	01			
	7.5		30	18.5	4	47	31		9.8418	
	8.5		30	27.3	5	46	27			
	9.5		30	38.2	6	39	45	0.1077	9.8835	
	10.5		30	50.7	7	28	04			
	11.5		31	04.8	8	12	06		9.9216	
	12.5		31	20.3	8	52	16			
	13.5		31	37.0	9	29	06	0.1199	9.9566	0.06
	14.5		31	55.0	10	02	54			
	15.5		32	14.1	10	34	02		9.9890	
	16.5		32	34.2	11	02	46			
	17.5		32	55.4	11	29	20	0.1324	0.0190	0.04
	18.5		33	17.6	11	54	05			
	19.5		33	40.6	12	16	49		0.0470	
	20.5		34	04.5	12	38	04			
	21.5		34	29.2	12	57	53	0.1449	0.0731	
	22.5		34	54.2	13	16	22			
	23.5		35	20.9	13	33	37		0.0976	
	24.5		35	47.9	13	49	45			
	25.5		36	15.6	14	04	53	0.1574	0.1205	0.02
	26.5		36	43.9	14	19	03			
	27.5		37	12.8	14	32	22		0.1422	
	28.5		37	42.3	14	44	52			
	29.5	23	38	12.5	−14	56	37	0.1698	0.1626	0.02


ORBIT OF THE EARTH
SUN
LINE OF NODES
LINE OF NODES
ORBIT OF COMET c 1905
ORBIT OF COMET b 1903
Oct. 11
Nov. 1
Nov. 9
Nov. 24
Dec. 9
Dec. 24
Jan. 8
Jan. 23
Dec. 1
Jan. 31
Jan. 16
Jan. 1
Mar. 1
Feb. 1
Mar. 1
Dec. 1

Elements and Ephemeris of Comet *b* 1905.—The following elements and ephemeris of Comet *b* 1905 (Schaer) have been communicated by the Superintendent of the U. S. Naval Observatory. They have been computed by Miss Eleanor A. Lamson, from observations made at Washington on Nov. 21, 23, 26.

ELEMENTS.

Time of passing perihelion	$= T =$ Oct. 25.734508 G. M. T.
Longitude of perihelion	$= \pi = 355°\ 35'\ 24''.8$
Longitude of node	$= \Omega = 222\ \ 55\ \ 37\ \ .7$
Inclination	$= i = 140\ \ 36\ \ 10\ \ .5$
Perihelion distance	$= q = 1.05197$
Residuals (O − C): $\cos\beta\,\Delta\lambda$	$= +\ 1.''9,\ \Delta\beta = +\ 1.''5$

HELIOCENTRIC COÖRDINATES.

$$x = r\,[9.955085]\ \sin(\ \ 6°\ 57'\ 18''.9 + v)$$
$$y = r\,[9.832045]\ \sin(\ 65\ \ 45\ \ 46\ \ .6 + v)$$
$$z = r\,[9.930305]\ \sin(114\ \ \ 6\ \ 25\ \ .6 + v)$$

EPHEMERIS.

G. M. T.	R. A. h	m	s	Dec. °	′	Light
1905 Dec. 3.5	23	30	8	+ 0	25.8	0.20
" " 7.5		30	19	− 4	47.4	0.10
" " 11.5		31	5	− 8	11.2	0.07
" " 15.5		32	15	−10	33.1	0.05
" " 19.5		33	41	−12	15.9	0.04
" " 23.5		35	21	−13	32.6	0.03
" " 29.5		37	13	−14	31.3	0.02
" " 31.5	23	39	15	−15	17.1	0.01

Brightness on Nov. 21 taken as unity.

Astronomical Bulletin.

Harvard College Observatory,
Cambridge, Mass., December 5, 1905.

Comet *b* 1905.—If you are by chance reproducing the contents of Lick Observatory Bulletins No. 86 and 87 in the next number of Popular Astronomy, I wish you would rectify two errors. In Bulletin 86 in the first column the parabolic residual should read + 2′ 12″ instead of − 38′ 35″. On the second page, in the ephemeris in the same bulletin, the minutes of the declination for December 6.5 should read 42′ instead of 47′.

You may be interested in the following residuals of comet *b* 1905. The elliptic orbit in Bulletin 86 gives the following residuals for an observation secured by Mr. Elliot Smith on Mount Hamilton, December 8, in the sense o—c:

$$\Delta\alpha = -\ 0^s.1$$
$$\Delta\delta = +\ 6''$$

The corresponding residuals from Miss Lamson's parabolic ephemeris are:

$$\Delta\alpha = -\ 0.^s6$$
$$\Delta\delta = +\ 13''.$$

The residuals for Miss Lamson's orbit for Aitken's observation of November 18 are

$$\cos\delta\Delta\alpha = -\ 2''$$
$$= -\ 20''.$$

The elliptic orbit is therefore right and the probabilities are that the period is even a little less than we make it. This is certainly getting down to fine points with the Short Method.

A. O. LEUSCHNER.

University of California, Berkeley,
December 11, 1905.

Comet *b*, 1905.—On account of the rapid motion of this object at the time of its discovery amounting to about 10' a day, it was at once seen that it was comparatively near the Earth. A plot was made of this portion of its orbit, using Leuschner's elements, to determine approximately the date of its nearest approach. Its distance was then computed for the date of November 19, 20, and 21. At this time it was nearly in opposition, although it differed from the Sun in right ascension by about 8^h. This is explained by its high northern declination. It was nearest the Earth on November 20, when its distance amounted to 0.251 units or 23,300,000 miles. Although not phenomenally close, yet comparatively few comets have passed nearer to the Earth than this one.

WILLIAM H. PICKERING.

December 2, 1905.

Comet *c* 1905 (Giacobini).—A telegram from Professor Kreutz at Kiel, Germany, December 7, announced the discovery of a bright comet by Giacobini at the Observatory at Nice, France, on December 6. This comet was then visible in the morning in Bootes, a few degrees east of Arcturus. The following observations are all that have come to hand:

Greenwich M. T.	R. A. h m s	Decl. ° ′ ″	Observer.
Dec. 6.6837	14 21 39.4	+20 59 29	Giacobini, (Nice)
7.9267	14 27 31.3	+20 26 36	Dugan(Princeton)
8.0311	14 28 01.0	+20 23 46	Smith (Lick)
9.0577	14 32 53.0	+19 55 36	Smith (Lick)

From the first three of these observations Mr. H. R. Morgan, of Glasgow, Missouri, has computed the following parabolic elements, which are only approximate but which represent the middle place exactly in latitude and within 8″ in longitude:

$T = 1906$ Jan. 16.2020 Gr. M. T.
$\omega = 213°\ 56'\ 06''$
$\Omega = 93\ 20\ 39$ } 1905.0
$i = 44\ 22\ 43$

$\log q = 8.96732$
$q = 0.09275$

The orbit of the comet according to these elements is shown in projection on the diagram with that of comet *b*. If these elements are anywhere near correct it is evident that the comet will rapidly approach the Sun and be lost to sight during the middle of January, but that it is likely to emerge from the solar rays in the latter part of January or in February, when it may be expected to be much brighter than it is now.

EPHEMERIS ACCORDING TO MORGAN'S ELEMENTS.

Gr. M. T.	R. A. h m s	Decl. ° ′	Brightness
Dec. 10.5	14 40 8	+19 13	1.66
14.5	15 01 28	+17 1	
18.5	15 24 56	+14 22	
22.5	15 50 48	+11 13	4.22

Later elements, obtained by Messrs. Crawford and Champreux from the first second and fourth of the above observations, differ somewhat from Mr. Morgan's elements and may be a little better than his. They too indicate that the comet is going in close to the Sun, but not so close as shown by Morgan's elements, so that the reappearance after perihelion will be later and under not quite so favorable conditions for observations.

ELEMENTS OF COMET *c* 1905.

Computed by R. T. Crawford and A. J. Champreux.

$T = 1906$ Jan. 24.7140 Gr. M. T.
$\omega = 193°\ 25'.5$
$\Omega = 91\ 36.0$ 1905.0
$i = 43\ 26.2$
$q = 0.27432$

EPHEMERIS.

Gr. M. T.	R. A. h m s	Decl. ° ′	Brightness
Dec. 11.5	14 45 07	+18 44.0	1.23
15.5	15 06 04	+16 32.7	
19.5	15 28 26	+14 01.5	
23.5	15 52 13	+11 08.6	2.59

Comet *d* 1905.—A telegram from Professor E. C. Pickering Harvard College Observatory received December 15, states that a comet was discovered by Slipher, of Lowell Observatory, on a photograph taken November 29.704 Gr M. T., in Right Ascension $22^h\ 44^m$ and declination $-11°\ 18'$. The Harvard Astronomical Bulletin No. 214 adds that the comet was moving 4′ per hour in a direction 15° north of west. The plate was exposed 57 minutes. Moonlight has since interfered with observation.

New Asteroids.—The new minor planets discovered by Wolf and his assistants at Heidelberg since our last note have increased from 1905 QY to 1905 SD.

VARIABLE STARS.

Variable Star Z Ceti.—From his observations of this star in 1904 and 1905 combined with the Heidelberg observations in 1902 and 1903 Mr. W. Luther, of Düsseldorf, determines the period to be about 187 days (*A. N.* 4052.) The star ranges from about 8.8 magnitude at maximum to about 12.0 at minimum. The next minimum will occur somewhere near June 14, 1906. The position of the star for 1900.0 is

$$\alpha = 1^h\ 01^m\ 38.^s93 \quad \delta = -2°\ 01'\ 01''.3.$$

New Variable 107.1905 Cygni.—In *A. N.* 4053 Mr. A. Stanley Williams of Hove, England, calls attention to a new variable of the β Lyræ type. Its position is

		h	m	s		°	′
1855	$\alpha =$	20	47	35	$\delta = +$	38	17.0
1900		20	49	18	$+$	38	27.1

The star is BD. + 38°.4262 magnitude 9.5. According to Mr. Williams the maximum brightness is 9.85 and the minimum about 10.75. At the secondary minimum the magnitude is about 10.15. The period is only fourteen hours, the elements determined by Mr. Williams from twenty-five photographic and 114

visual observations being

Principal minimum = 1899 Oct. 8 $13^h\ 10^m$ (Gr. M. T.) + $0^d\ 14^h\ 01^m\ 37^s.7$ E
= J. D. 2414936.5487 + 0.584464 E.

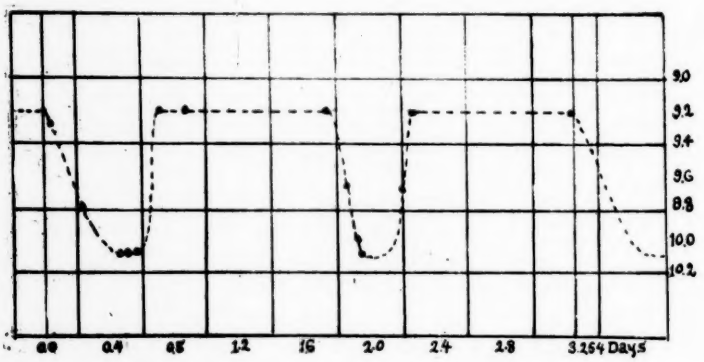
The following list of comparison stars is given:

Star	BD. No.	BD. Mag.	α 1900.0			δ 1900.0		Photographic Light Scale	Visual Scale	Visual Mag.
	°		h	m	s	°	′			
A	+ 38.4260	8.0	20	48	55	+ 38	25.9	59.2	81	8.00
B	+ 38.4257	8.6		48	21		32.2	38.7	58	8.92
b	+ 38.4261	9.4		48	58		32.4	36.2	38	9.72
c				48	36		35.0		36	9.80
d				49	00		28.1	18.0	18	10.52
e			20	49	08	+ 38	30.0	11.4	12	10.76

New Variable 108.1905 Capricorni.—In *A. N.* 4053 Mr. P. Götz of Heidelberg, Germany, announces a new variable star, probably of the Algol type with a period of 3.254 days. Its position for 1900.0 is

$$\alpha = 20^h\ 55^m\ 55^s.14 \qquad \delta = -15^\circ\ 37'\ 06''.1$$

It is ordinarily of magnitude 9.2 and descends to 10.1 at minimum. There are apparently two minima in each period at intervals of 1.75 and 1.50 days. The



Light Curve of 108.1905 Capricorni.

change of light is the same in both but in one the waning and increase occupies $0^d.72$ and in the other only $0^d.52$.

The following list of comparison stars is given:

Star	BD. No.	BD. Mag.	Photographic Mag.
	°		
a	−15.5863	9.1	9.1
b	−15.5865	9.2	9.3
c	−15.5869	9.5	9.6
d	−15 5866	10	9.8
e	−15.5862	9.4	10.0

The variable is 9′ directly north of BD. −15°.5863.

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours.]

U Cephei.

	d	h
Feb.	1	14
	4	2
	6	14
	9	2
	11	14
	14	1
	16	13
	19	1
	21	13
	24	1
	26	13

Z Persei

Feb.	2	14
	5	15
	8	16
	11	18
	14	19
	17	20
	20	22
	23	23
	27	1

Algol.

Feb.	1	16
	4	13
	7	10
	10	6
	13	3
	16	0
	18	21
	21	18
	24	14
	27	11

RT Persei

Feb.	1	6
	2	3
	2	23
	3	19
	4	16
	5	12
	6	8
	7	5
	8	1
	8	22
	9	18
	10	14
	11	11
	12	7
	13	4
	14	0
	14	20
	15	17
	16	13
	17	10
	18	6
	19	2
	19	23
	20	19
	21	15
	22	12

RT Persei

Feb.	23	8
	24	5
	25	1
	25	21
	26	18
	27	14
	28	11

λ Tauri

Feb.	3	12
	7	11
	11	10
	15	8
	19	7
	23	6
	27	5

R Canis Maj.

Feb.	1	18
	2	21
	4	1
	5	4
	6	7
	7	10
	8	14
	9	17
	10	20
	11	23
	13	3
	14	6
	15	9
	16	13
	17	15
	18	18
	19	21
	21	1
	22	4
	23	7
	24	10
	25	14
	26	18
	27	21

Y Camelop.

Feb.	3	5
	6	12
	9	19
	13	3
	16	10
	19	17
	23	1
	26	8

RR Puppis

Feb.	4	17
	11	3
	17	14
	24	0

V Puppis.

Feb.	1	16
	3	3
	4	13
	6	0
	7	11
	8	22
	10	9
	11	20
	13	7
	14	18
	16	5
	17	16
	19	2
	20	13
	22	0
	23	11
	24	22
	26	9
	27	20

S Cancri.

Feb.	5	17
	15	5
	24	16

S Antliæ.

Feb.	1	2
	2	1
	3	0
	4	0
	4	23
	5	22
	6	22
	7	21
	8	20
	9	20
	10	19
	11	18
	12	18
	13	17
	14	17
	15	16
	16	15
	17	15
	18	14
	19	13
	20	13
	21	12
	22	11
	23	11
	24	10
	25	9
	26	9
	27	8
	28	7

S Velorum.

Feb.	4	6
	10	4
	16	3
	22	1
	28	0

W Urs. Maj.

Period 4^h 0.2^m

Feb. 1-14 13^h

Feb. 15-28 14^h

RR Velorum

	d	h
Feb.	1	2
	2	23
	4	19
	6	16
	8	12
	10	9
	12	5
	14	2
	15	22
	17	19
	19	15
	21	12
	23	8
	25	5
	27	1
	28	22

Z Draconis.

Feb.	2	8
	3	17
	5	2
	6	10
	7	19
	9	3
	10	12
	11	20
	13	5
	14	14
	15	22
	17	7
	18	15
	20	0
	21	8
	22	17
	24	2
	25	10
	26	19
	28	3

δ Libræ

Feb.	1	10
	3	18
	6	2
	8	10
	10	18
	13	2
	15	10
	17	17
	20	1
	22	9
	24	17
	27	1

U Coronæ

	d	h
Feb.	3	2
	6	13
	9	23
	13	10
	16	21
	20	8
	23	19
	27	6

R Aræ

Feb.	4	17
	9	3
	13	13
	18	0
	22	10
	26	20

U Ophiuchi.

Feb.	1	10
	2	6
	3	2
	3	22
	4	18
	5	14
	6	11
	7	7
	8	3
	8	23
	9	19
	10	15
	11	11
	12	7
	13	4
	14	0
	14	20
	15	16
	16	12
	17	8
	18	4
	19	0
	19	21
	20	17
	21	13
	22	9
	23	5
	24	1
	24	21
	25	17
	26	14
	27	10
	28	6

Z Herculis

Feb.	1	17
	4	19
	6	16
	8	19
	10	16
	12	19
	14	16
	16	19

Z Herculis.

	d	h
Feb.	18	16
	20	19
	22	16
	24	19
	26	16
	28	18

RS Sagittarii.

	d	h
Feb.	1	3
	3	13
	5	23
	8	9
	13	4
	15	14
	18	0
	20	10
	22	20
	25	6
	27	16

V Serpentis.

	d	h
Feb.	2	15

V Serpentis.

	d	h
Feb.	6	2
	9	13
	13	0
	16	11
	19	21
	23	8
	26	19

RX Herculis.

	d	h
Feb.	1	7
	2	4
	3	2
	3	23
	4	20
	5	18
	6	15
	7	12
	8	10
	9	7
	10	4
	11	2
	11	23

RX Herculis.

	d	h
Feb.	12	20
	13	18
	14	15
	15	12
	16	10
	17	7
	18	4
	19	2
	19	23
	20	20
	21	18
	22	15
	23	12
	24	10
	25	7
	26	4
	27	2
	27	23
	28	20

RU Lyræ

	d	h
Feb.	3	7

RU Lyræ.

	d	h
Feb.	6	21
	10	12
	14	2
	17	17
	21	7
	24	21
	28	12

U Sagittarii.

	d	h
Feb.	3	9
	6	18
	10	3
	13	12
	16	22
	20	7
	23	16
	27	1

SY Cygni.

	d	h
Feb.	3	10
	9	10
	15	10
	21	10
	27	10

WW Cygni.

	d	h
Feb.	1	11
	4	18
	8	2
	11	10
	14	17
	18	1
	21	9
	24	16
	28	0

SW Cygni.

	d	h
Feb.	5	6
	9	20
	14	10
	19	0
	23	13
	28	3

VW Cygni.

	d	h
Feb.	8	21
	17	8
	25	18

Variable Stars of Short Period not of the Algol Type.

The times of maxima only are given; the times of minima may be obtained by subtracting the interval printed in parentheses under the name of the star.

Y Aurigæ

	(— 0	18)
	d	h
Feb.	3	7
	7	4
	11	1
	14	21
	18	18
	22	14
	26	11

T Monocerotis

	(— 7	22)
	d	h
Feb.	9	2
Mar.	8	2

W Geminorum

	(— 2	16)
	d	h
Feb.	3	19
	11	13
	19	7
	27	0

ζ Geminorum

	(— 5	0)
	d	h
Feb.	8	17
	18	21

V Carinæ

	(— 2	4)
	d	h
Feb.	7	13
	14	6
	20	23
	27	15

T Velorum

	(— 1	9)
	d	h
Feb.	2	23
	7	14
	12	6
	16	21
	21	12
	26	4

W Carinæ

	(— 1	0)
	d	h
Feb.	4	10
	8	19
	13	4
	17	13
	21	22
	26	7

S Muscæ

	(— 3	11)
	d	h
Feb.	8	7
	17	23
	27	14

T Crucis

	(— 2	1)
	d	h
Feb.	1	5
	7	23
	14	16
	21	10
	28	3

R Crucis

	(— 1	9)
	d	h
Feb.	4	16
	10	12
	16	7
	22	3
	27	23

S Crucis

	(— 1	12)
	d	h
Feb.	3	6
	7	22
	12	15
	17	7
	22	0
	26	16

W Virginis

	(— 8	4)
	d	h
Feb.	8	13
	25	19

V Centauri

	(— 1	12)
	d	h
Feb.	3	2
	8	14
	14	1
	19	13
	25	1

R Triang. Austr.

	(— 1	0)
	d	h
Feb.	3	4
	6	13
	9	23
	13	8

R Triang. Austr.

	d	h
Feb.	16	17
	20	3
	23	12
	26	21

S Triang. Austr.

	(— 2	2)
	d	h
Feb.	7	3
	13	11
	19	19
	26	3

S Normæ

	(— 4	10)
	d	h
Feb.	1	6
	11	0
	20	19

R V Scorpii

	(— 1	10)
	d	h
Feb.	2	19
	8	21
	14	22
	21	0
	27	1

X Sagittarii

	(— 2	21)
	d	h
Feb.	7	16
	14	16
	21	16
	28	17

Y Ophiuchi

	(— 6	6)
	d	h
Feb.	12	14
Mar.	1	17

W Sagittarii

	(— 3	0)
	d	h
Feb.	6	19
	14	10
	22	0

Y Sagittarii

	(— 2	2)
	d	h
Feb.	5	12
	11	7
	17	1
	22	20
	28	15

U Sagittarii

	(— 3	0)
	(— 6	14)
	d	h
	13	8
	20	2
	26	20

β Lyræ

	(— 3	9)
	(— 3	2)
	d	h
Feb.	5	5
	11	16
	18	3
	24	14

κ Pavonis		U Vulpeculæ		SU Cygni		S Sagittæ		T Vulpeculæ	
d	h	d	h	d	h	d	h	d	h
(− 4	9)	(− 2	3)	Feb. 18	6	(− 3	10)	(1−	10)
Feb. 5	19	Feb. 6	16	22	2	Feb. 7	6	Feb. 1	11
14	21	14	15	25	22	15	16	5	22
23	23	22	15			24	1	10	8
								14	18
U Aquilæ		SU Cygni		η Aquilæ				19	5
(− 2	5)	(− 1	8)	(− 2	9)	X Cygni		23	15
Feb. 1	8	Feb. 2	20	Feb. 3	16	(− 6	19)	28	2
8	8	6	17	10	20	Feb. 11	1		
15	9	10	13	18	0	27	10		
22	9	14	9	25	4				

Approximate Magnitudes of Variable Stars on Dec. 10, 1905.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.
T Androm.	0	17.2	+26	26	9.6*d*	R Camelop.	14	25.1	+84	17	9.2 *i*
T Cassiop.	0	17.8	+55	14	12	R Bootis	14	32.8	+27	10	13
R Androm.	0	18.8	+38	1	14.7*d*	S Librae	15	15.6	−20	2	*s*
S Ceti	0	19.0	— 9	53	13.8*d*	S Serpentis	15	17.0	+14	40	*s*
S Cassiop.	1	12.3	+72	5	14*d*	S Coronae	15	17.3	+31	44	*s*
R Piscium	1	25.5	+ 2	22	12.8*d*	S Urs. Min.	15	33.4	+78	58	8.0
U Persei	1	52.9	+54	20	10.6*d*	R Coronae	15	44.4	+28	28	*s*
R Arietis	2	10.4	+24	36	9.5 *i*	V "	15	45.9	+39	52	*s*
o Ceti	2	14.3	— 3	26	6.0 *i*	R Serpentis	15	46.1	+15	26	*s*
S Persei	2	15.7	+58	8	9.5*d*	R Herculis	16	1.7	+18	38	*s*
R Ceti	2	20.9	— 0	38	11.0 *i*	R Scorpii	16	11.7	−22	42	*s*
U "	2	28.9	−13	35	12.3*d*	S "	16	11.7	−22	39	*s*
R Trianguli	2	31.0	+33	50	8.0 *i*	U Herculis	16	21.4	+19	7	*s*
R Persei	3	23.7	+35	20	9.3 *i*	W Herculis	16	31.7	+38	32	13 *d*
R Tauri	4	22.8	+ 9	56	10.5*d*	R Draconis	16	32.4	+66	58	12.5*d*
S "	4	23.7	+ 9	44	14.5 *f*	S Herculis	16	47.4	+15	7	*s*
R Aurigæ	5	9.2	+53	28	12.5*d*	R Ophiuchi	17	2.0	−15	58	*s*
U Orionis	5	49.9	+20	10	11.9*d*	T Herculis	18	5.3	+31	0	12.5*d*
R Lyncis	6	53.0	+55	28	7.5 *i*	R Scuti	18	42.2	— 5	49	5.2 *i*
R Gemin.	7	1.3	+22	52	9.5*d*	R Aquilae	19	1.6	+ 8	5	12.5*d*
S Canis Min.	7	27.3	+ 8	32	7 *i*	R Sagittarii	19	10.8	−19	59	*s*
R Cancri	8	11.0	+12	2	7.5	S "	19	13.6	−19	12	*s*
V "	8	16.0	+17	36	9.5*d*	R Cygni	19	14.1	+49	58	12.7 *i*
S Hydrae	8	48.4	+ 3	27	9.5 *i*	RT "	19	40.8	+48	32	7.3 *i*
T "	8	50.8	— 8	46	*u*	X "	19	46.7	+32	40	7.3 *i*
R Leo. Min.	9	39.6	+34	58	8.0*d*	S "	20	3.4	+57	42	14.5 *f*
R Leonis	9	42.2	+11	54	9.5 *i*	RS "	20	9.8	+38	28	8.0
R Urs. Maj.	10	37.6	+69	18	13.5 *f*	R Delphini	20	10.1	+ 8	47	12 *i*
R Comae Ber.	11	59.1	+19	20	12 *d*	U Cygni	20	16.5	+47	35	8.0*d*
T Virginis	12	9.5	— 5	29	*s*	V "	20	38.1	+47	47	13.7*d*
R Corvi	12	14.4	−18	42	*s*	T Aquarii	20	44.7	— 5	31	11.3*d*
Y Virginis	12	28.7	— 3	52	*s*	R Vulpec.	20	59.9	+23	26	7.5 *i*
T Urs. Maj.	12	31.8	+60	2	8.0 *i*	T Cephei	21	8.2	+68	5	9.3 *i*
R Virginis	12	33.4	+ 7	32	*s*	S "	21	36.5	+78	10	10.5*d*
S Urs. Maj.	12	39.6	+61	38	12.0*d*	S Lacertae	22	24.6	+39	48	9 8*d*
U Virginis	12	46.0	+ 6	6	*s*	R "	22	38.8	+41	51	12.5 *i*
V "	13	22.6	— 2	39	*s*	S Aquarii	22	51.8	−20	53	8.3 *i*
R Hydrae	13	24.2	−22	46	*s*	R Pegasi	23	1.6	+10	0	10.5*d*
S Virginis	13	27.8	— 6	41	*s*	S "	23	15.5	+ 8	22	9.7*d*
R Can. Ven.	13	44.6	+40	2	12*d*	R Aquarii	23	38.6	+15	50	9.5 *i*
S Bootis	14	19.5	+54	16	13.5	R Cassiop.	23	53.3	+50	50	*f*

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that the light is increasing; *d*, that the light is decreasing; *s*, that it is near the Sun; and *u*, that its magnitude is unknown.

From observations made at the Leander McCormick, Vassar College, Whiteside and Harvard Observatories.

GENERAL NOTES.

The Presidency of the Astrophysical Society. Professor Simon Newcomb, of Washington, D. C. has been the president of the Astronomical and Astrophysical Society from the time of its organization. The choice was a fitting one, and his continuance in the office, so far as we know, would have met the hearty and universal wish of the members of the society. But on being solicited to do so we makes the following reply to Secretary Comstock:

"It is now six years since, during my absence abroad, our Society elected me as its first President. This action, and my re-election at successive annual meetings up to the present time by men who have made the title "American astronomer" one to be proud of, I have felt to be one of the great honors of my life, and have appreciated it accordingly.

It seems to me that the time has now come when the best interests of the Society will be promoted by my retirement from the office, and the election of some one of our eminent associates to what may well be considered a very high position in the astronomy of our country. I therefore ask that you will signify to the Society my declination of a further election as its President.

In taking this course I wish all the members to be assured that my active interest in the success of the Society will not be in any way abated. I shall continue to promote its interests to the best of my powers, and especially in the case of meetings held in Washington, and shall attend all meetings held elsewhere when possible.

I consider the work of the Society of great importance to the progress of science on this side of the Atlantic. Through it we share in the advantage enjoyed by the promoters of the other branches of pure and applied science which flow from mutual help, counsel, criticism and friendly interest. I therefore earnestly hope that the Society will increase in numbers, and that its meetings will be of yet greater interest and advantage to all the members who are able to attend them.

The Echo Mountain Fire. From the Sunday and Monday *Times* of Los Angeles, December 10 and 11, we obtain some information of the destructive fire that swept over the sides, ravines and summit of Mount Lowe on Saturday, December 9, from early morning throughout the day. It was difficult at the time of writing the first reports, to estimate the damage to property caused by the desolation of the fire. Accounts are in conflict as to the origin of the fire and of the acreage which its dreadful work covered. Buildings are in ruins, the cable incline is damaged, trees and shrubbery are swept away and a black, forbidding field of many hundreds of acres in just a few hours replaced that scene of beauty on Echo Mountain's sides that was the delight of those who knew them well, or, even, to those who had paid these charming regions but a single visit.

The famed Alpine Tavern, several miles beyond Mt. Lowe and the white buildings of the great Solar Observatory where Professor Hale and his staff of astronomers and observers are located was untouched by the ravages of the fire. It will be a matter of profound thankfulness from the circle of astronomical science the world over, that the great undertaking of the Carnegie Institution for further study of the Sun, on Echo Mountain, under the direction of Professor Hale was not hindered or stopped temporarily. It was feared that the delicate instruments of the Solar Observatory would be injured by the heat of the raging fires near by, so the delicate parts of them were hastily removed, during the morning and sunk in the waters of the reservoir. So far as known at this writ-

ing no real injury came to the Observatory. The little village of structures on the top of Echo Mountain was destroyed by the flames; the pavilion was blown down and burned; the Pacific Electric Power-House was destroyed; the upper trestle of the incline railway was burned, and the great cable which cost 12000 dollars was more or less damaged. To prevent further damage the workmen cut the huge cable and it was allowed to roll down to the bottom of the long, steep incline with a violence that sounded like a peal of thunder. The illustrated account in the *Times* of this great storm and fire is a creditable one.

Astronomical and Astrophysical Society of America. The seventh annual meeting of the Astronomical and Astrophysical Society will be held at Columbia University, New York City, beginning on Thursday, December 28, 1905. In the announcement of this meeting, by circular November 28, the secretary, Professor George C. Comstock, said: "It is hoped that the customary railway rate of one and one-third fares for a round trip, upon the certificate plan, may be obtained, and provisional arrangements for this have been made with the Trunk Line Passenger Association, and are pending with other associations. Members are advised, on purchasing railway tickets for the meeting to ask for a certificate which will be issued without charge. Application for this certificate should be made some time in advance of the departure of trains, and the certificate must be brought to the meeting and be deposited with Miss F. E. Harpham, Columbia University, who will be in attendance for that purpose, in Room 404, Fayerweather Hall on Friday, December 29. It is essential that certificates be deposited in time to receive validation from a special agent of the railroads, who will be in attendance for that purpose on the 29th. A fee of 25 cents will be charged by the railroads for the validation of each certificate."

The following statement of routes in New York City is furnished by Professor Harold Jacoby, acting for the Local Committee of Arrangements, Messrs. Jacoby and Poor, and Mrs. Henry Draper.

"The Manhattan and Grand Union Hotels both adjoin the Grand Central Station where trains arrive by the New Haven road as well as the New York Central road. Members arriving by any of the Hudson River Ferries, such as land passengers from the Pennsylvania Railroad, Jersey Central Railroad or Erie Railroad, can reach the hotels by taking the nearest elevated railway to 42nd street, where a crosstown trolley car will take them directly to the hotel doors. The University can be reached from the hotels in about fifteen minutes, by taking a subway express train. There is a subway station adjoining both hotels, and another adjoining the University buildings.

Members desiring to proceed directly from the Grand Central Station to the University can do so by subway, using the stations already mentioned. To reach the University directly from the ferries, it is best to inquire the way to the nearest subway station. In all cases members must take Broadway subway trains to reach the University without change.

A meeting of the Council will be held in Room 406 Fayerweather Hall, Columbia University, at 11 A. M. on December 28, and the first meeting of the Society will occur in Room 304, Fayerweather Hall, at 2 P. M. of the same day. Other scientific sessions will be held on December 29 and, if necessary, on December 30. Members of the Society in attendance are invited to be present at a luncheon tendered the Society, on Friday, December 29, by the Department of Astronomy of Columbia University. Provision will be made on Thursday and Saturday for furnishing luncheon at the University, at a cost not exceeding fifty cents per member to those who desire it. In order that due provision may be made for this service it is essential that those who desire to avail themselves of it shall on or before December 23, advise Professor Harold Jacoby, Columbia University, New York, of their intent to be present. The evening of December 29 is reserved for a reception that will be tendered to members of the Society by Mrs. Henr Draper at her home, 271 Madison Ave.

Members are requested to register in Room 404 Fayerweather Hall, Columbia University, before 2 P. M. of December 28, if possible.

Titles of papers to be presented to the Society may be filed with the Secretary at Madison, Wis., at any time prior to December 23, and titles thus filed will be given precedence in the program over those submitted at a later date. The attention of members is especially invited to the following action of the Council: "*Resolved*, That titles submitted to the Council after its second session at any

regular meeting of the Society will not be placed on the program."

In accordance with the provisions of the Constitution and By-Laws of the Society, successors to the following named officers are to be elected at the New York meeting, viz.:

President	Simon Newcomb
First Vice-President	George E. Hale
Second Vice-President	William W. Campbell
Secretary	George C. Comstock
Treasurer	Charles L. Doolittle
Councilor	E. C. Pickering
Councilor	R. S. Woodward

Members who do not expect to be present at the meeting are requested to send to the Secretary their nominating ballots for these offices in accordance with Section 2 of the By-Laws".

Errata. On page 45 of this issue for Sun's right ascension read $8^h\ 54^m\ 41^s.62$ and Moon's right ascension read $20^h\ 54^m\ 41^s.62$.

PUBLISHER'S NOTICES.

Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

All Drawings for publication should be done in India ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of engraving now most generally used.

Proofs will generally be sent to authors living in the United States, if copy is furnished before the first of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

Renewals.—Notices of expiration of subscription are sent directly after the last number of this publication for which payment has been made. It is especially requested that subscribers will send renewal, or order for renewal, promptly as this publication will not be continued beyond the time for which it has been ordered.

Astronomical News.—It is very much desired on the part of the management, that brief news paragraphs of astronomical work in all the leading observatories of the United States be furnished to this publication, as regularly and as often as possible.

The work of amateur astronomers, and the mention of "personals" concerning prominent astronomers will be welcome at any time.

The building and equipping of new observatories, the manufacture, sale or purchase of new astronomical instruments, with special reference to improvements and new designs, and the results of new methods of work in popular language, will be deemed very important matter and will receive prompt attention. It is greatly desired that all persons interested bear us in mind and promptly respond to these requests.

Messrs. Wm. Wesley & Son, 28 Essex Street, Strand, London, England, are our sole European agents.

Reprints of articles for authors, when desired, will be furnished in titled paper covers at small cost. Persons wanting reprints should order them when the manuscript is sent to the publisher. They cannot be furnished later without incurring much greater expense.

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Back volumes or single numbers are still on sale at the old prices, $2.50 and 30 cents, respectively.

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Northfield, Minn., U. S. A.